Instructional Benefits of a Web-Based Students' Concurrent Course Registration Tool

Dr. Ke Tang, University of Illinois Urbana-Champaign

Ke Tang is a Teaching Assistant Professor in the Department of Mechanical Science and Engineering at the University of Illinois Urbana-Champaign. Dr. Tang's research focuses on engineering education, particularly on student-centered pedagogies, data-driven instruction, and interdisciplinary education.

Dr. Thomas Golecki, University of Illinois at Urbana - Champaign

I spent 10+ years in industry as an engineer in structural mechanics and structural health monitoring projects, earning professional licensure as PE and SE. My PhD research focused on the structural optimization of dynamic systems including random loading and vehicle-bridge interaction. Now as teaching faculty, I try to connect course concepts to real-world examples in a way that motivates and engages students.

Dr. Jennifer R Amos, University of Illinois Urbana-Champaign

Dr Amos joined the Bioengineering Department at the University of Illinois in 2009 and is currently a Teaching Professor in Bioengineering.

Prof. Jacob Henschen, University of Illinois Urbana-Champaign

Professor Henschen completed his B.S., M.S., and PhD. at the University of Illinois Urbana-Champaign in 2007, 2009, and 2018 respectively. He was an Assistant Professor at Valparaiso University until he moved to the University of Illinois Urbana-Champaign as a Teaching Assistant Professor in June 2020. He serves as the co-chair for the Teaching Methods and Education Materials Committee at ACI and the co-chair of the Committee on Faculty Development at ASCE.

Dr. Abdussalam Alawini, University of Illinois at Urbana - Champaign

Dr. Abdussalam Alawini is a teaching associate professor in the School of Computing and Data Science at the University of Illinois Urbana-Champaign. His research interests are broadly in database systems and computing education. In particular, he is interested in the application of AI technologies in facilitating active learning activities and improving online assessments. Dr. Alawini is very passionate about teaching. His teaching excellence is evidenced by his consistent recognition in the 'Excellent Teachers Ranked by their Students' over several semesters and his receipt of the 2024 Campus Excellence in Undergraduate Teaching award.

Dr. Matthew D Goodman, University of Illinois Urbana-Champaign

Dr. Goodman received degrees in Materials Science and Engineering from Iowa State University (B.S. & M.S.) and the University of Illinois (Ph.D.). Currently, he is a senior lecturer in the Materials Science and Engineering Department at University of Illinois and a Siebel Center for Design Affiliate. There, he teaches introductory materials science courses to non-majors as well as the major-specific capstone sequence, utilizing and emphasizing the Human-Centered Design framework.

Dr. Halim Beere, University of Illinois Urbana-Champaign

Dr. Beere is a Web Application Developer for the College of Engineering at the University of Illinois Urbana-Champaign. He holds a Doctor of Musical Arts in Music Composition from the School of Music at the same university, with research focused on algorithmic composition and the "livecoding" performance practice. In his current role, he builds and maintains web applications that support education and research, blending technical expertise with creative problem-solving.

Instructional Benefits of a Web-Based Students' Concurrent Course Registration Tool

Abstract

Data-driven approaches have the potential to reshape course design and lesson planning in modern education by providing instructors with actionable insights into student learning environments. A web-based tool has recently been developed to offer instructors real-time access to students' concurrent course registration data. Initially developed to help instructors highlight interdisciplinary connections between courses, the tool has shown broader potential for enhancing course design and instructional strategies. By revealing key information, such as how many students are concurrently enrolled in prerequisites or are taking high-demand courses simultaneously, instructors can adjust their lesson plans or provide special instructional help to better accommodate students' academic needs and workloads.

This tool uses a table and a histogram to present the collected students' course registration data (both student numbers and percentages) and allows the users to select the concurrent registration data and the cumulative registration data. Users are allowed to set the cutoff percentage to control the number of data to be presented on the webpage.

A beta version of this tool was first released to a group of faculty in various departments who teach a range of courses, from introductory classes with hundreds of students to advanced electives with only a handful of students. The preliminary feedback on the tool has been tremendously positive with many faculty reporting that this helps them better understand their students. Following this positive feedback, version 1.0 of the tool was released to the faculty of the entire College of Engineering. Surveys and interviews were conducted to investigate what information instructors retrieve, the point of the semester of this retrieval, and, most importantly, how this information is utilized by instructors to improve educational and pedagogical efforts. Further analysis is focused on the value and application of such information to explore and assess the contribution of this new tool for data-driven instruction.

Introduction

Data-driven instruction is centered on using various student data to guide education practice. Data-driven instruction has continued to attract interest for its promise to help address institutional objectives as well as increase the quality and standardization of instruction at the course level [1, 2].

Instructors, informed by student data, can gain an insight into student learning environments and progress and then reshape course design and lesson planning [3]. To facilitate data-driven instruction, numerous learning analytics tools have been developed to collect, analyze, and visualize student data. The tools can be as simple as spreadsheets and be easily applied to show

student performance data in charts [1]. Such simple data collection and visualization can help instructors with data-informed decision making to adjust their lesson plans. More advanced and powerful tools are also available and widely used. For example, Moodle, Canvas, and Paradiso are all platforms under the Learning Management Systems (LMS) [4] that can manage course instruction materials, schedule, assignments, grading, and discussion forums, as well as provide student performance analysis reports. Recently, quite a few new tools, e.g. CampusLabs, Nuro Retention, AirClass, etc., have been developed by combining data-driven approaches with artificial intelligence [5]. Such new data-driven tools can help with student performance assessment, retention and dropout prediction, classroom monitoring, etc.

In this study, a web-based tool was developed to offer instructors real-time access to students' Concurrent Registration Data (CRD). Initially developed to help instructors highlight interdisciplinary connections between courses, this CRD tool provides instructors with valuable student registration data which has shown broader potential for enhancing course design and instructional strategies. By revealing key information, such as how many students are concurrently enrolled in prerequisites or are taking high-demand courses simultaneously, instructors can adjust their lesson plans or provide special instructional help to better accommodate students' academic needs and workloads.

In the seven months since the CRD tool was released to the faculty of the entire College of Engineering in September of 2024, there have been over 300 unique users, representing nearly 40% of the faculty. Both surveys and interviews have been conducted to investigate what information instructors retrieve and, most importantly, how this information is being used by instructors to improve their educational and pedagogical efforts.

This paper provides a detailed introduction to the user interface and the functionalities of this new tool. The survey and interview results are subsequently presented and discussed with a focus on the value and application of the information retrieved from the data to explore and assess the contribution of this new tool for data-driven instruction.

Concurrent Registration Data Tool

The CRD tool is designed to be quick and easy for instructors to access. Rather than making the data available on a new website that instructors would need to actively seek out, we worked with the Engineering IT department to make the tool available within the existing web portal for all instructors within the College of Engineering. Now, in addition to the other frequently used tools such as viewing course rosters, editing course websites, etc., a new option for viewing the CRD is available in a location instructors are already familiar with.

Data Aggregation

Instructors at our university are provided access to their own rosters but course registration data for other courses are not available to individual instructors. Access to the database of registration information is limited to college-level staff and administration and is administered securely server-side. In order to ensure that instructors are not gaining information about students that they would otherwise be denied access to, student data is anonymized before being displayed in the

CRD, and no individually identifiable information is displayed to the user of the tool.

The university assigns unique numeric codes, referred to as Course Reference Numbers (CRNs), to each course session, such as lectures, discussions, laboratory sections, etc. When courses have multiple components, such as a lecture and lab, a student may be registered in two different CRNs for a single course. To compensate for this, the CRD tool compiles student numbers for the course, not each individual CRN. Additionally, cross-listed courses where two sections with different CRNs meet together can be combined into a single registration record or displayed separately.

The student data is aggregated through a series of SQL database operations. The process begins by identifying the complete cohort of students through a join operation between the course table and student registration data, matching on course CRN and semester identifiers. To capture the concurrent registration information, a second join is performed with the student registration data, this time matching on student IDs while applying appropriate temporal constraints — either filtering for the current term when displaying the concurrent registration or allowing all past terms when displaying cumulative historical data.

This results in a table of all courses being taken by that cohort within the defined time window. Each row of data also includes the count of overlapping enrollments. To facilitate the secondary course overlap functionality discussed in the next section, the query also provides course-specific student lists as comma-delimited strings of unique identifiers. These lists allow the tool to calculate additional enrollment intersections while maintaining student privacy, as no identifying information is exposed through the user interface.

After gathering and aggregating the data, it is then processed client-side to create the user interface. The tool dynamically updates the HTML table structure, calculates and applies CSS styles for the visual histogram elements, and implements JavaScript handlers to respond to user input. This client-side processing creates the interactive visualization described in the following section.

Visualization

The aggregated data consists of a list of courses students are concurrently enrolled in, along with the total number of students enrolled in that course. The data is visualized as an ordered table, where the first column indicates the course numbers with the instructor's course listed first. The second column indicates the number of students enrolled, and the third column shows this value as a percentage of the current course. To clearly indicate the data being presented corresponds to students in a selected section, the first row is highlighted and this enrollment is considered as 100%. The remaining rows of the table are ordered by the enrollment value. Because this list can get very long for large courses, the user is also provided with an optional threshold input, which hides the rows for courses with enrollment percentages below the specified threshold. This threshold can be set to zero to see the entire data set. An example of the CRD tool is shown in Figure 1.

In this example, ME340 is the instructor's course, which consists of 204 students. Among these students, 145 (71.1%) are simultaneously enrolled in ME370, 96 (47.1%) are simultaneously

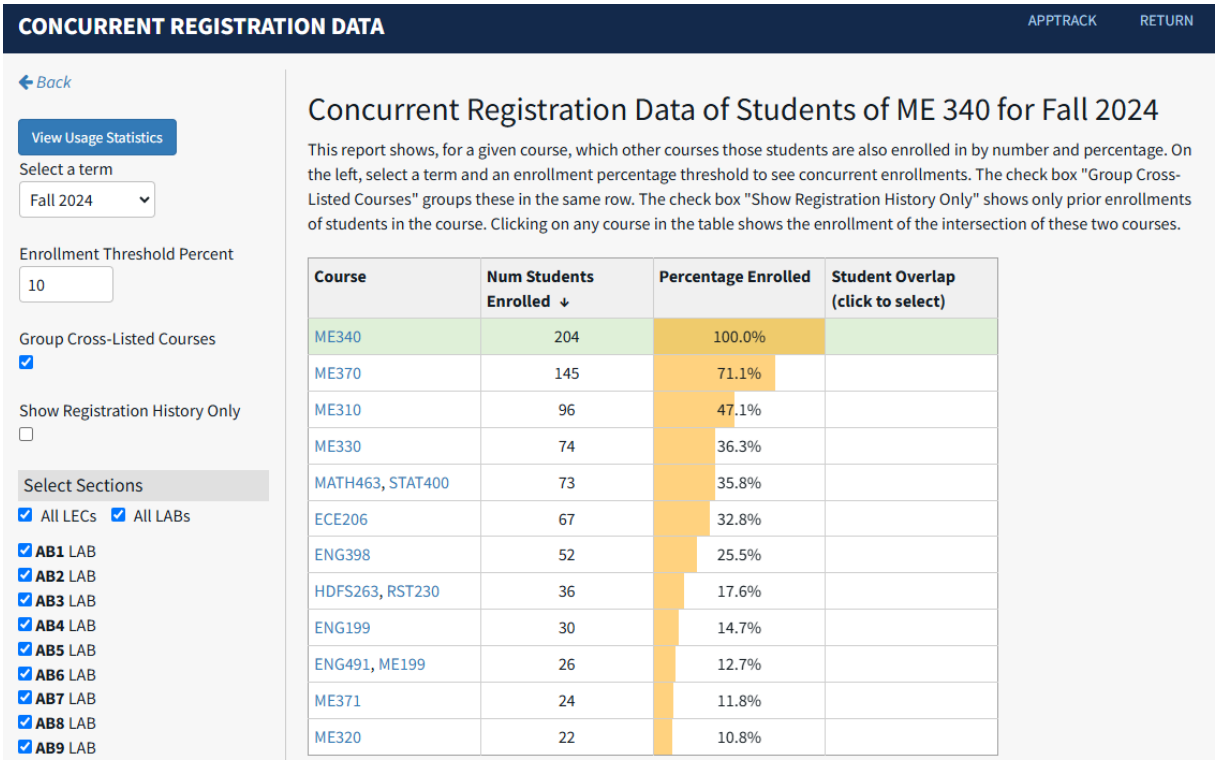

Figure 1: Concurrent registration data visualization example.

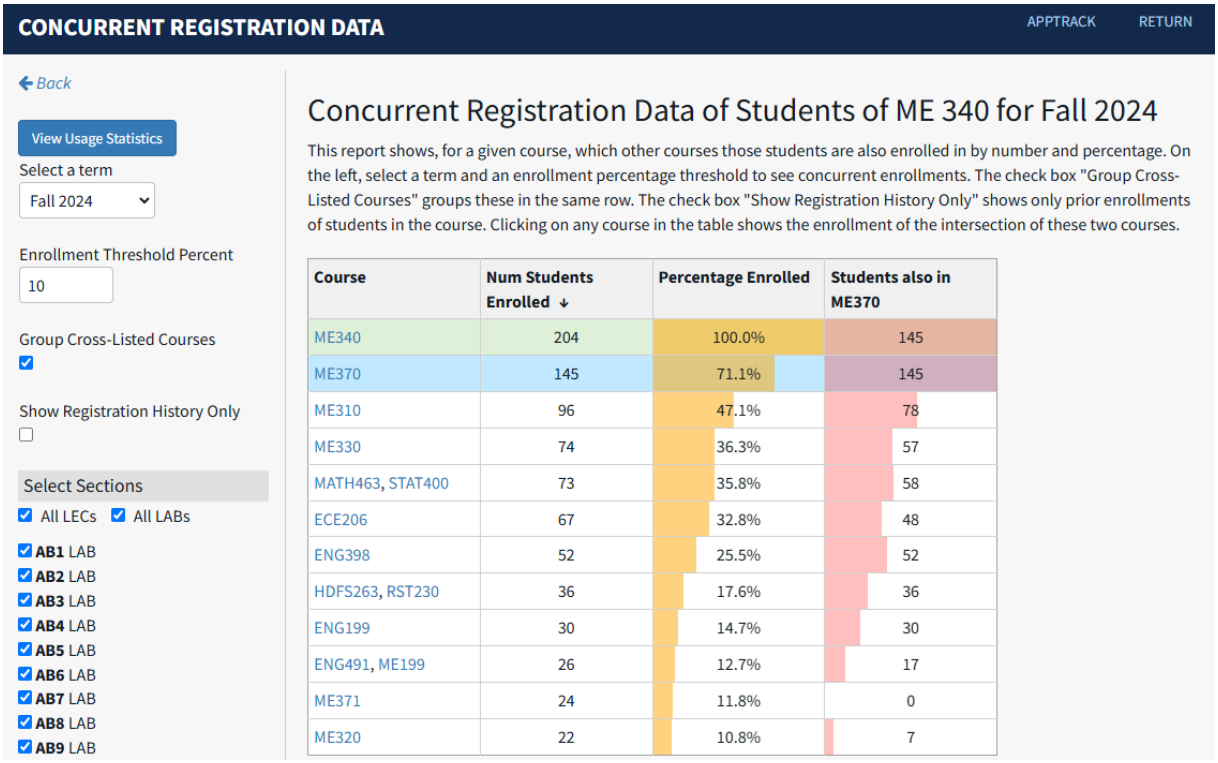

Figure 2: Concurrent registration data showing additional selected course.

enrolled in ME310, and so on. Courses with multiple names, such as MATH463 and STAT400 are cross-listed courses, that is, these are one course with multiple CRNs. The courses listed in the first column include only the abbreviation, these are hyperlinked to the course catalog which includes other information such as a brief description of the course, schedule, instructors, prerequisite(s) etc. Additionally, the third column includes a horizontal bar, a visual indication of the percentage enrolled.

Feedback from early users included a request to see concurrent registrations in more than one course, i.e. a cohort of students concurrently registered in three common courses. This is facilitated by the user clicking on any row of the table, which populates a fourth column indicating the number of students in this cohort. This is shown in Figure 2. For instance, of the 145 students simultaneously enrolled in ME340 and ME370, clicking on the ME370 column shows that 78 of them are also enrolled in ME310. That is, there is a cohort of 78 students simultaneously enrolled in these three courses.

Additionally, users can access the cumulative course registration data by checking the box for "Show Registration History Only".

Methods

Anonymous surveys were distributed to faculty in the College of Engineering who used the tool within the first two months of its release. The survey has two questions designed to gather the demographic data of participants.

- What is your job title?
- What is your primary department?

The following questions have been used in the survey to learn how faculty use the CRD tool and gather their feedback.

- At what points in the semester do you use this tool?
- Rate your level of agreement with the statement that the concurrent course registration data provided by this tool are useful for course instruction.
- Share any examples of how the concurrent course registration data help with your course instruction.
- Rate your level of agreement with the statement that the cumulative registration data provided by this tool are useful for course instruction.
- Explain in what ways the cumulative registration data are useful for course instruction.
- Rate your level of agreement with the statement that this tool helps identify connections between my course and other courses that students are concurrently enrolled in, as well as courses they have previously taken.
- Would you be interested in using this tool to help identify interdisciplinary connections for your students?

- How satisfied are you with the overall functionality of the tool?
- How would you rate the user interface of the tool?
- Is there anything you wish the tool could do that it currently does not? Please explain.
- Rate your level of agreement with the statement that the tutorial materials are necessary for new users of this tool.
- Share any additional feedback or recommendations for improving the CRD tool.

Semi-structured interviews have been conducted to further explore how faculty found out about the CRD tool, what information they gathered from the data presented by this tool, how they used such information in their course instruction, their thoughts on the idea of identifying and highlighting the connections between courses for the objective of interdisciplinary education, etc. To recruit interviewees, the last question in the survey asked if the participant was willing to participate in an interview about the CRD tool, although the survey is anonymous.

Results and Discussion

Survey Results and Discussion

The survey received 27 responses. Demographics for participants are broken down in Figure 3. The results are broken down by title. 25.9% of the participants are tenure track or tenured faculty, including assistant professor (11.1%), associate professor (11.1%), and full professor (3.7%). Our institution also has non-tenure tracks of specialized faculty. The specialized faculty respondents were 74.1% teaching specialized faculty, including teaching assistant professor (37.0%), teaching associate professor (3.7%), teaching full professor (11.1%), lecturer (7.4%), senior lecturer (7.4%), and others (7.4%, one clinical associate professor and one head teaching assistant).

The demographics also captured the primary departments for each faculty member. Figure 4 shows the participants were from 8 departments of the College of Engineering, i.e. Aerospace Engineering, Bioengineering, Civil and Environmental Engineering, Computing and Data

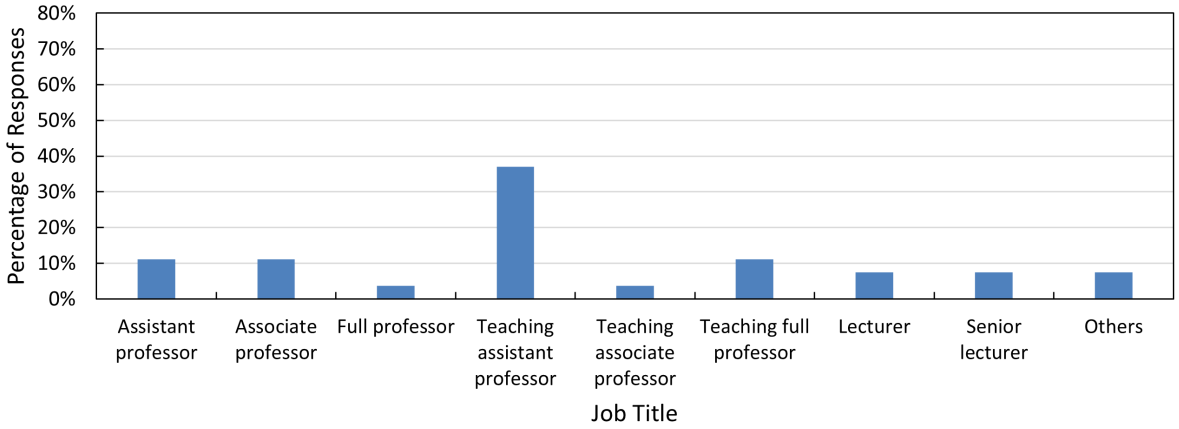

Figure 3: Job title of the participants.

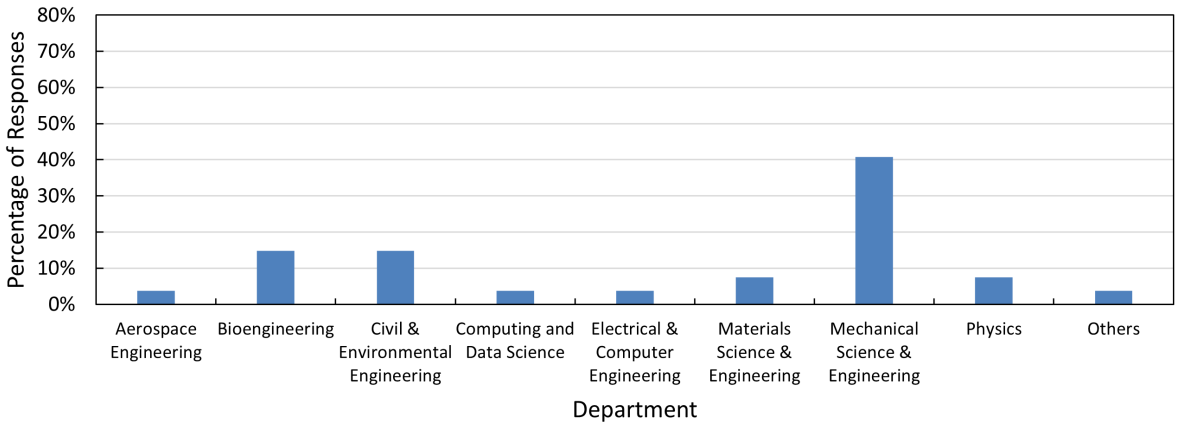

Figure 4: Department of the participants.

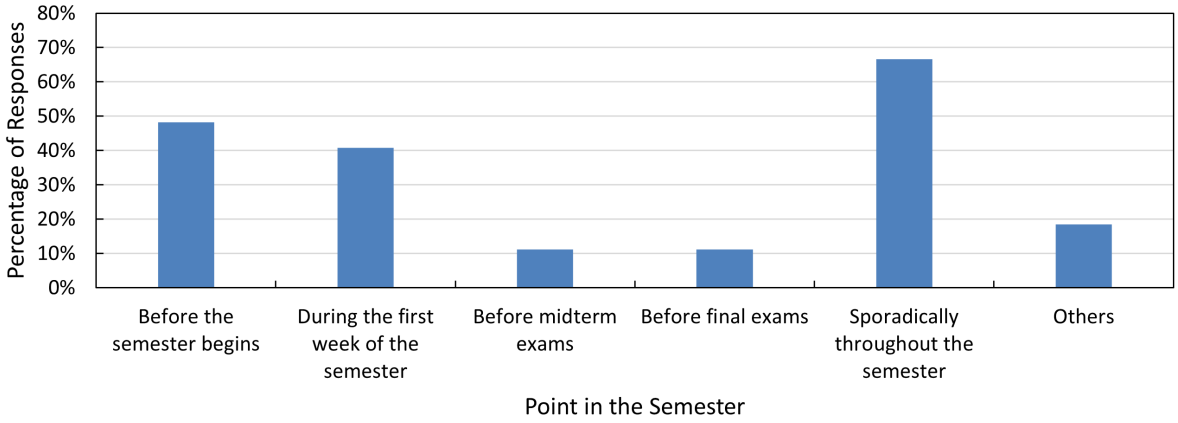

Figure 5: Point in the semester to use the CRD tool.

Science, Electrical and Computer Engineering, Materials Science and Engineering, Mechanical Science and Engineering, and Physics.

Figure 5 shows at what points of the semester instructors use the CRD tool. The participants were allowed to select all the options that apply. Agreeing with our initial thoughts, this tool is most likely used before the semester begins (48.1%) and during the first week of the semester (40.7%) when instructors work on the course instruction plan. However, it is surprising that the option of "sporadically throughout the semester" received the most votes (66.7%), which means that most of the impact this tool provides is throughout the semester, instead of only to the course instruction plan at the beginning of the semester.

Figures 6 shows the instructors' feedback on the usefulness of the concurrent course registration data provided by the CRD tool. Results show that 66.6% of the participants voted for "agree" or "strongly agree" on the statement that the concurrent course registration data provided by this tool are useful for course instruction, 14.8% voted for "disagree" or "strongly disagree", and 18.5% were neutral. The answers to the corresponding open-ended question, provided by the participants

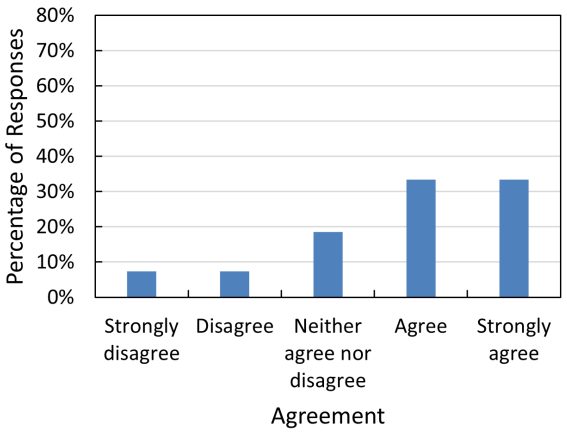

Figure 6: Agreement with the statement that the concurrent course registration data provided by the CRD tool are useful for course instruction.

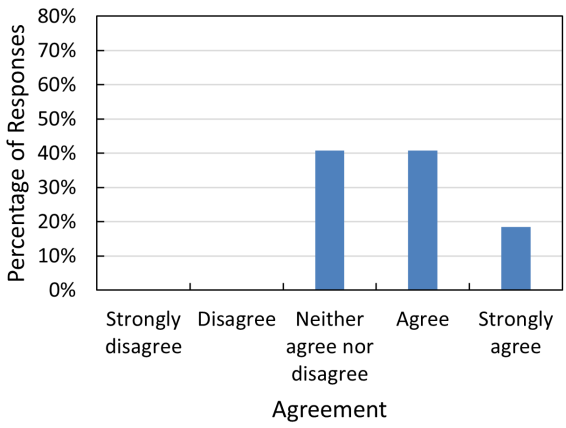

Figure 7: Agreement with the statement that the cumulative registration data provided by the CRD tool are useful for course instruction.

who voted for "agree" or "strongly agree", indicate that the concurrent course registration data helped with checking if there were any courses that many students were enrolled in that the instructor was not aware of, understanding the students' workload regarding the concurrent course enrollment, making relevant connections to other courses students are taking to spark the learning interest and scaffold the new concepts, fine-tuning the lecture presentations, figuring out suitable schedule of office hours, scheduling around other courses' events like large project deadlines and exams, learning how many students were concurrently enrolled in the co-requisite course, etc. For the participants who voted for "disagree" or "strongly disagree", many cited that knowing what courses students are concurrently enrolled in will not change how they deliver their course. These faculty rely on the assumption that the students have completed all the necessary prerequisites. Others who disagreed responded that they "don't use this tool" which indicates they have no interest in it.

Besides the concurrent course registration data, the CRD tool also provides the cumulative course registration data for all the courses students have already taken. Figure 7 shows the instructors' feedback on the usefulness of the cumulative course registration data. Results show that 59.3% of the participants voted for "agree" or "strongly agree" that the cumulative course registration data provided by this tool are useful for course instruction, 0% voted for "disagree" or "strongly disagree", and 40.7% were neutral. The answers to the corresponding open-ended questions indicate that the cumulative course registration data helped instructors to learn what courses, besides the required prerequisites, students have already taken so that they can potentially build a model of the students' knowledge base to inform their teaching. This might change how quickly or slowly the instructors move through some portions of their course or adjust the content covered. Another way in which the instructors used the cumulative course registration data was to identify and highlight the connections between the new concepts of their courses to concepts students have learned from their previous courses. This reinforces good pedagogy to scaffold learning and build upon what students already know. The responses also indicate that the instructors teaching the

courses which have the students outside of their departments can benefit from the data provided by this tool since the instructor might not be familiar with the curricula of other departments. Conversely, some participants mentioned that they didn't see how to get the cumulative course registration data from the tool interface, suggesting that a tutorial might be necessary.

Figure 8 shows 70.4% of the participants agreed that the CRD tool helps identify connections between their course and other courses that students are concurrently enrolled in, as well as courses they have previously taken. Figure 9 indicates that 70.4% of the participants are interested in using the CRD tool to help identify interdisciplinary connections for their students.

As shown in Figures 10 and 11, 77.8% of the participants are satisfied with the overall

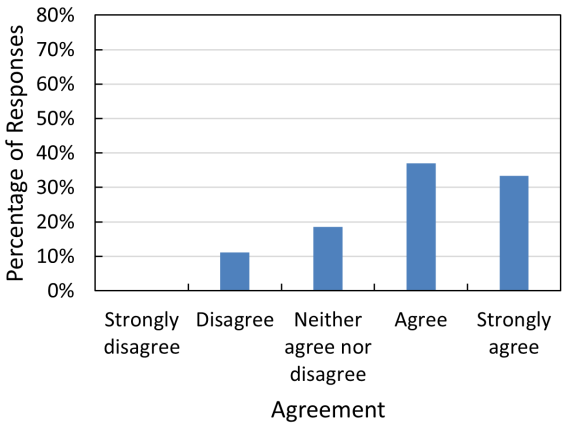

Figure 8: Agreement with the statement that the CRD tool helps identify connections between my course and other courses that students are concurrently enrolled in, as well as courses they have previously taken.

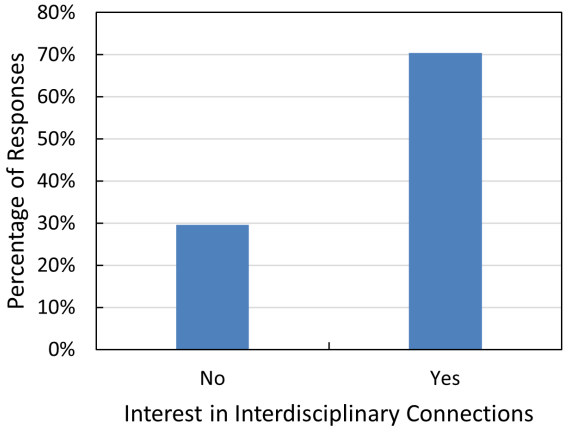

Figure 9: Interest in using the CRD tool to help identify interdisciplinary connections for students.

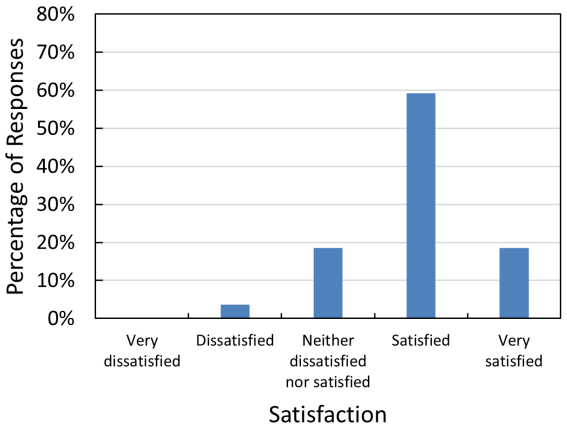

Figure 10: Satisfaction with the overall functionality of the CRD tool.

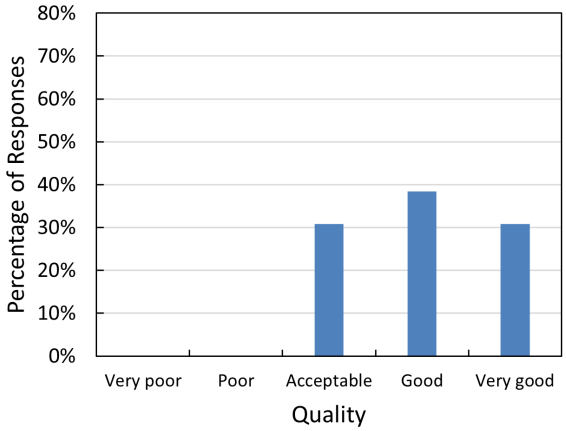

Figure 11: Quality of the user interface of the CRD tool.

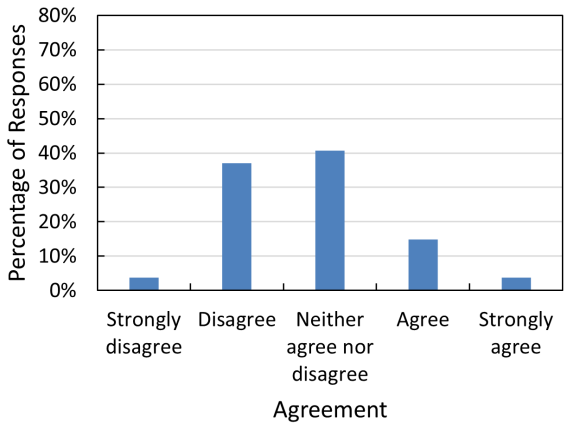

Figure 12: Agreement with the statement that the tutorial materials are necessary for new users of this tool.

functionality of the CRD tool and 69.2% voted for "good" or "very good" regarding the tool interface. Although less than 20% of the participants agreed that the tutorial materials are necessary for new users of this tool as presented in Figure 12, clear needs of the tutorial materials have been identified in the answers to the open-ended question about additional feedback or recommendations for improving the CRD tool. The developers plan to make a short tutorial video to facilitate the usage of the CRD tool and the full understanding of the data provided by this tool.

Additionally, we also learned from the survey results that some of the participants had never heard about the CRD tool before receiving this survey. This indicates that more efforts need to be made to promote the CRD tool in our institution.

Interview Summary

Three instructors who volunteered to be interviewees by responding to the corresponding question of the survey were interviewed.

The first interviewee is a teaching full professor. She mostly used this tool to learn the percentage of her students concurrently enrolled in other courses. In this way, she can provide reasonable options for her office hours for students. She communicated with other instructors of courses that had a large overlap of enrollment to coordinate midterm exam days. She also mentioned the cumulative course registration data were quite useful. She knew her students took courses in the Department of Chemistry previously, but didn't know what courses in the Department of Chemistry her students took before her class. Additionally, her course relies on certain mathematical concepts like calculus. Now she can access the historical registration data of the math courses which made her feel she has a better understanding of her students' preparation. She also emphasized that this tool might be more useful for a class with a large enrollment, e.g. a core course of undergraduate students, since such classes generally have a significant overlap of student enrollment with other courses. For a class with a small enrollment, e.g. an elective course or a graduate course, the courses students register in will have smaller overlaps and the value of

the course registration data might be less. This tool might also be more useful for new faculty who might not be familiar with the curriculum. She mentioned that instructors who are familiar with the contents of various courses might identify the connections between courses easily by knowing only the titles of the courses, but it might be challenging for instructors who are not familiar with the content of other courses. Thus, she suggested an improvement to show the connections between courses by content overlap.

The second interviewee is a lecturer. He teaches an upper level course where students have diverse backgrounds. His interest in the cumulative course registration data focused on what courses his students have taken prior to his. It was helpful for him to learn students' backgrounds so that he can tailor the delivery of his course content. He gave an example about teaching numerical methods which can be taught through the problem scenarios of different disciplines, e.g. fluid mechanics, heat transfer, etc. When using the tool, he found that some of his students had not taken a heat transfer course. This aligned with feedback he had received that the course was challenging to learn the numerical method if he used a heat transfer scenario. Similar to the first interviewee, he suggested adding the title of the courses beside the course numbers so that the instructor can quickly learn what this course is about. He also believes the function of filtering out the data for the several courses of interest might be helpful. For example, the cumulative course registration data may show dozens of courses, and the instructor may not be interested in all of these courses. The instructor may be interested in a few relevant courses, e.g. Solid Mechanics, Fluid Mechanics, and Heat Transfer, so it would be helpful if the tool could filter out the data for the courses of interest.

The third interviewee is a teaching full professor as well as an academic adviser. He reported using the CRD tool to help with scheduling the office hours, exams, and project deadlines for the course he was teaching, as well as avoiding the time conflicts of courses for the duty of planning and arranging courses as an academic adviser. For instance, he was working on adding a section of an existing course due to the increase in the number of students who need to take this course. The concurrent course registration data provided him with a succinct list of courses that students are taking concurrently so that he could take this into account to avoid time conflicts. However, since the current CRD tool does not provide the time information of courses, he had to toggle back and forth between the CRD tool and the website course explorer to collect the information. Accordingly, he suggested the time information of courses should be collected and presented by the CRD tool. He also suggested that administrative staff regarding academic advising and course management should be exposed to this tool. In addition, he highlighted the value of helping students identify the connections between courses for both the education within a curriculum of one department and for the interdisciplinary education involving the curricula of various departments. In his opinion, having the instructors know the connections first allows them to help their students see the connections, and the CRD tool is on the right track in this direction.

Conclusion

A web-based students' concurrent course registration data tool was developed for the initial objective to help instructors identify and highlight interdisciplinary connections between courses regarding interdisciplinary education. However, when the tool was made available, instructors retrieved various information from the data based on their interests. To better understand the

instructional benefits of this new tool, surveys and interviews were conducted to collect the instructors' feedback. The survey and interview results indicate:

- The concurrent registration data are helpful for instructors with scheduling the learning activities, e.g. exams, projects, office hours, etc., to avoid the students' hard time of heavy workload and also time conflict regarding participation. Meanwhile, the concurrent registration data also show potential to help faculty with planning and arranging courses regarding academic advising and course management.
- The cumulative registration data are helpful for instructors to learn the students' backgrounds and tailor their course delivery regarding a better match with the students' backgrounds for better learning outcomes.
- Both the concurrent and the cumulative registration data help instructors identify the connections between courses. Identifying and highlighting connections for students are a best practice and can spark learning interest, help scaffold new concepts, and reinforce interdisciplinary education.
- The course registration data provided by the CRD tool are generally more useful for a class with a large enrollment which has larger overlap of student enrollment with other courses.
- The course registration data provided by the CRD tool are more useful for a class with students from departments other than the instructor's department.
- New faculty who are not familiar with the curricula may need more instruction on how to use the CRD tool and more information about what each listed course is, e.g., title and course description.

A few suggestions for improving this new tool emerged, so our team will continue to develop the tool based on this feedback. There is a need to

- Collect and present the course titles beside the course numbers.
- Collect and present the course time information along with the concurrent registration data.
- Collect and present content overlap information.
- Create a short tutorial video.
- Integrate administrative staff, especially academic advisors and course managers, as users.

The IT department of the College of Engineering assisted in developing the CRD tool based on existing student course registration data. To ensure ease of access, this new tool has been integrated into the existing web portal, which instructors regularly use for course-related information. All higher education institutions have their own student course registration data. However, these data may not be accessible to instructors in an appropriate format. We hope our work demonstrates the value of the concurrent and cumulative course registration data from the viewpoint of data-driven instruction. We hope that this paper motivates other higher education institutions to develop their own tools for their instructors using already available data in new ways.

Additionally, our initial goal was to identify and highlight connections between courses to support interdisciplinary education. Although student course registration data can help instructors recognize these connections, the CRD tool does not provide direct information about them. To further advance our objective, the authors plan to develop technology capable of identifying connections between concepts taught in different courses.

Acknowledgment

The authors appreciate the support of the IT department of the Grainger College of Engineering, University of Illinois Urbana-Champaign. We would also like to acknowledge the Grainger College of Engineering Strategic Instructional Innovations Program (SIIP) for the funding for this project.

References

[1] P. Bambrick-Santoyo, *Driven by data 2.0: A practical guide to improve instruction*, 2nd ed. Jossey-Bass, 2019.

[2] O. Viberg, M. Hatakka, O. Bälter, and A. Mavroudi, "The current landscape of learning analytics in higher education," *Computers in human behavior*, vol. 89, pp. 98–110, 2018.

[3] V. Park and A. Datnow, "Ability grouping and differentiated instruction in an era of data-driven decision making," *American Journal of Education*, vol. 123, no. 2, pp. 281–306, 2017.

[4] L. Sanchez, J. Penarreta, and X. Soria Poma, "Learning management systems for higher education: a brief comparison," *Discover Education*, vol. 3, p. 58, 2024.

[5] K. Ahmad, W. Iqbal, A. El-Hassan, J. Qadir, D. Benhaddou, M. Ayyash, and A. Al-Fuqaha, "Data-driven artificial intelligence in education: A comprehensive review," *IEEE Transactions on Learning Technologies*, vol. 17, pp. 12–31, 2023.