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USING TEACH BACK TUTORIALS TO OVERCOME PANDEMIC LEARNING GAPS

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ABSTRACT

Aim/Purpose	The purpose of this paper is to address the issue of gaps in students' knowledge at the time they enter a comprehensive Information Systems capstone course. This problem of knowledge gaps was exacerbated by the forced remote learning and isolation caused by the COVID-19 pandemic. The aim was to find a technique that would identify and fill those gaps. Ideally, the method would also reinforce the students' interpersonal soft skills.
Background	Many universities have a capstone course where students may apply their knowledge from the curriculum to a project, and they are evaluated on their retention of knowledge from the core classes. Over the past two years, students have experienced course interruptions and modifications due to the pandemic, resulting in learning gaps on topics covered in the core courses. Depending on the project's scope and curriculum, this may prevent students from conversing on many essential concepts during the capstone course. By requiring students to create "Teach Back" tutorials on materials from their core courses, faculty may ensure that the key concepts are discussed multiple times within the curriculum.
Methodology	We present a case study to identify key concepts and compare cohort results before and after implementation.
Contribution	A process for identifying potential knowledge gaps is identified, and a method to repeatedly expose students to concepts is introduced.
Findings	There were improvements to the overall capstone scores after the tutorial implementation. While many factors influence changes in scores across cohorts, the initial findings are promising, supporting the concept that teaching back helps to close knowledge gaps.

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Recommendations for Practitioners	Faculty should collaborate to identify knowledge areas that need to be reinforced later in their students' academic careers. Teaching back essential concepts that may not be prioritized in implementing a capstone project ensures a repeated exposure to the identified concepts.
Recommendations for Researchers	There needs to be a priority to teach students to be lifelong learners and to teach the skills needed to share their knowledge with future coworkers. There needs to be more research into a pedagogy that builds these essential soft skills within our curriculum. Finally, research into alumni feedback on course topics and pedagogy is needed.
Impact on Society	Introducing pedagogy that improves both knowledge and soft skills, this research looks to build individuals who will learn independently and be able to communicate with and improve others.
Future Research	There needs to be additional research to study the changes in technical knowledge before and after Teach Back, the consequences of elective sequencing, the consideration of elective versus required courses, and the use of Teach Back to capture student knowledge gained from completing diverse electives prior to the capstone course.
Keywords	knowledge gaps, pandemic, Teach Back, capstone, soft skills, interpersonal skills, curriculum, engagement, tutorials

INTRODUCTION

Information Systems (IS) education involves sets of technical skills that require repetition to be conversant in terminology and concepts. For many IS students, their primary job will not be to perform day-to-day technical tasks but to act as the facilitators between the business units and technology. For faculty, developing students with sufficient technical background and effective soft skills to communicate technical concepts is essential. Ideally, a capstone course can provide a real-world experience in which the student can exercise and demonstrate those skills and the knowledge they have acquired during their studies.

Attempts have been made to pair students with an organization where they can execute their capstone project. The challenges of an educational-practice partnership often prove incompatible with the capstone course requirements. Not the least of these problems is when the organization prevents students from completing their projects within the organization or on time (Shake & Lavin, 2018). Then, there is the simple practicality of having the project scope fit within the course timeframe.

If projects with partner companies are not practical or do not cover all the desired aspects, how best to achieve similar results in a classroom setting? Active learning concepts engage the student rather than the more passive role of traditional lecture-based courses. Houghton and Stewart (2017) evolved a capstone course from lecture-based to a model emphasizing student engagement. Over three iterations, active learning replaced all traditional lectures and tutorials with interactive, project-based activities. The result was better student engagement, higher satisfaction, and improved demonstration of capstone skills.

The research for this paper involved students in an undergraduate Information Systems capstone course in the Southern United States. Because of the comprehensive nature of the capstone, students need to draw upon knowledge from each of their prior IS courses. Over the past two years, many courses have had interruptions or modifications due to the COVID pandemic. Students have also been impacted personally through absences and isolation. The result is that students are coming into the capstone course with critical knowledge gaps from their core IS courses. The challenge for the faculty was how to overcome these gaps in a way that was both efficient and engaging for the students.

To that end, this research was initiated to answer three questions:

1. Given the comprehensive nature of a capstone course, in which knowledge areas do our students have learning gaps?
2. How can we identify and address learning gaps that exist within students in the capstone course?
3. Can the learning gaps be addressed in such a way that it will improve the students' soft skills while reinforcing areas of knowledge weakness?

How best to reinforce highly technical IS concepts and ensure that the students have a clear understanding? Doctors and nurses have a similar problem when trying to ensure that patients have a clear understanding of the technical details of their diagnosis and treatment. As a result, the "Teach Back" method was developed to improve and verify patient retention. Teach Back is a method used primarily in medical settings to ensure that patients have heard their instructions correctly. Could the same technique be used to reinforce concepts in an Information Systems course? That is the motivation behind this research.

Resistance from instructors has been one of the obstacles to implementing active learning concepts (Roseler et al., 2018). This may be because university instructors are subject matter experts in their field, but they often lack any training in pedagogy (Wright et al., 2004). It is hoped that this paper will encourage the adoption of the Teach Back method by providing specific implementation details.

In the following section, we will review the literature and explain constructivism and the Teach Back method, specifically. This will be followed by the details of our case study. Future Research and the limitations of this study will then be offered. Finally, the conclusion will review the answers to our research questions.

LITERATURE REVIEW

This literature review will establish the background for the teaching approach in this paper. We begin with a discussion of the capstone course setting for our study. Then, the conceptual foundation of constructivism will be explained, leading to a discussion of active learning by flipping the classroom. Finally, the specific method of "Teach Back" will be explained.

CAPSTONE

Melonçon and Henschel (2013) offer the following definition for a technical capstone course:

> [the capstone course] provide[s] students the opportunity to bring together all their technical program courses into a singular cumulative experience. Usually required in the final term of the degree program, the cumulative experience offers another and more comprehensive way to assess students' competency of the program's curriculum through a demonstration of the knowledge and multiple skills acquired throughout their course of study. (p. 51)

Their definition underlies this research. Hauhart and Grahe (2015) found that most capstone courses are project-driven and completed in a single semester. While some programs have students work on projects with actual clients, that can cause two major problems (Melonçon & Schreiber, 2018). First, the client's project requirements may not offer the scope to let the students adequately demonstrate their abilities. Second, it is difficult to align the timing of client projects and the given semester. While the timing may be overcome by using an instructor-created project, the issue with the scope can create gaps in the extent of the program topics covered. Additionally, project-driven courses may present challenges to assess the extent to which the project has prepared the student to achieve the stated Program Outcomes (Sasipraba et al., 2020).

Constructivism

The teaching method employed in this study is based on constructivism, which is the theory that students actively learn by combining prior knowledge with new experiences and interactions (Cristea, 2015). To be effective, students must have the opportunity to engage in interesting, relevant, and challenging experiences. Most significantly, the learner must take an active role in synthesizing this new knowledge (Utley, 2011).

Practical implementation of constructivism takes the form of active learning by the students. Roseler et al. (2018) identified the actions of both teachers and students that comprise an active learning environment. For students, these include reading, writing, speaking, observing, and "doing" (e.g., building or manipulating). Instructor actions include explaining, facilitating dialog, facilitating activities, and waiting.

Next, we look at flipping the classroom.

Flip the Classroom

Traditional lecture (TL) has been the primary method for instruction at the university level. Criticism of TL generally focuses on the passivity of the students, which makes TL unsuited for teaching higher-level skills like analysis and application (Tahir et al., 2020). The flipped classroom is an increasingly popular pedagogical approach that has some advantages over TL. With "Flip the Classroom" (FTC), the students prepare outside of class time through reading, videos, or pre-recorded lectures (Davenport, 2018). McNally et al. (2017) noted that the search term "flipped classroom" has steadily increased on Google since 2011 and is projected to continue that trend.

One of the challenges for this course is that students must demonstrate technical problem-solving skills, which is an area where FTC can be applied. Chis et al. (2018) combined FTC with problem-based learning (PBL) in a technical programming course. They recorded a 26.56% increase in assessment results when -PBL was used primarily instead of TL being the primary mode.

Davenport (2018) found that FTC even worked effectively for group projects. Students found a high level of effectiveness and satisfaction when preparing collaboratively. The students did request occasional short lectures to introduce or amplify a particular topic. That said, flipping the entire course has been shown to increase student engagement and results (McNally et al., 2017).

Teach Back

There are various implementations of FTC. One technique for FTC is a method called Teach Back (TB). Research has shown that patients leaving an emergency room, hospital, or doctor's office often have poor recall of their discharge information (Mahajan et al., 2020). TB was developed to ensure that patients understand their discharge information or instructions from medical personnel.

Comprehension and retention are greatly improved through TB. Mahajan et al. (2020) did a large comparative study. Patients who engaged in TB had a 40% improvement in the retention of critical information. After TB, the percentage of patients with a comprehension deficit was reduced from 49% to 11.9%. Higher education has implemented various methods similar to TB such as Oxford Tutorials and peer teaching. However, tutorials can be seen as not being cost-effective as they are time-consuming for instructors and inappropriate for large classes (Balwant & Doon, 2021). Little research appears to have been done in strictly utilizing student-led tutorials to supplement a project-driven course.

Students' main objection to FTC is the substantial preparation time compared to TL (Ward et al., 2018) for each student. Depending on implementation, TB may have one advantage over other FTC methods. Students only need to prepare their tutorial topic and then be receptive to the other

students' tutorials. Other FTC methods require each student to review all expected review topics before the class.

Students are expected to use a variety of technical skills but are also expected to practice soft skills, including effective communication and team building. In addition to the benefit of improved knowledge retention, TB has also been shown to improve communication skills (MacLean et al., 2018). Complex communication is the ability to elicit relevant information and convey a meaningful interpretation of it. It is a requirement for students entering the workforce today (National Research Council, 2011).

CASE STUDY METHODOLOGY

The case study methodology is appropriate for evaluating a new process (Meyer, 2001) and evaluating instruction (Tellis, 1997). One common characteristic of case studies is that the investigator takes on an interactive role with the other participants (Leedy, 1997), which is applicable in the case of the capstone course where the instructors are the principal investigators. Using a case study in intrinsic cases where the principal investigator is involved in the outcome is appropriate (Tellis, 1997). Case studies should use multiple forms of evidence to support research propositions (Meyer, 2001).

OUR CASE

Our institution has four required subjects for the Information Systems (IS) concentration: data communications and networking (DCM), database (DB), business programming (BP), and systems analysis and design (SAD). The students also choose two elective courses. The capstone exam covers only the four core courses and is given during the SAD course.

While the SAD course has a project component, there is no guarantee that all the concepts from the core curriculum will be significant components of the project. The IS faculty saw the need to reinforce the core concepts even if they were not a requirement of their course project. To this end, the student groups were instructed to create tutorials related to the core processes that would be like conducting a "lunch and learn" tutorial in an organization. The initial gap analysis began prior to the pandemic and became more important as project components were shifted and in-class meetings disrupted during the pandemic beginning in the spring semester of 2020.

Using gap analysis, the faculty identified critical concepts from the core courses that required additional exposure (Table 1). In addition, input from our Industry Advisory Board guided the emphasis on given topics. In constructivism, the students need to take learned knowledge and apply it to a problem. Therefore, the tutorials should cover general theory and terminology and then apply the knowledge to reflect and apply in a new situation. Ideally, the tutorial should be connected to a deliverable that is required during the project; however, if they are not directly connected to the course project, they can be connected to the project loosely by incorporating them into the further development of a particular project. The tutorials were implemented with the instructor initially meeting with each student or group and holding a question-and-answer session to explain the desired level of detail and connection to the project. Next, the students submitted a preliminary narrated tutorial to the instructor for feedback. Finally, the student or group presented their tutorials during class time. The class was instructed that test questions may be taken from the presentations.

The following sections illustrate selected tutorial assignments made for the three concept areas that the Capstone exam covers, excluding the SAD course.

Table 1. Teach back tutorial topics

Topics Tested	Data Communications and Networking	Database	Business Programming	System Analysis and Design Project	Added for Tutorial Exposure
Principles of Data Communications	I,P				
Local and Wide Area Networks	I,P				
Wireless Technologies	I,P			I	
Technology Convergence	I,P			I	
Compression Techniques	I,P				
Network Security	I,P			I	Y
Network Reliability	I,P			I,P	Y
Network and Technology Diagrams	I,P			I,P	Y
Service Level Agreements	I,P			I	Y
Process and Data Modeling		I,P,C		I,P,C	Y
Database Design		I,P,C		I,P,C	Y
Creating Data Structures		I,P,C		I,P,C	
Connecting to Data Sources		I,P,C		I,P,C	
Processing Data		I,P,C		I,P,C	
DDL		I,P,C		I,P,C	
DML		I,P,C		I,P,C	
Business Rules		I,P,C		I,P,C	Y
Programming Fundamentals			I,P,C		
Program Structure			I,P,C		Y
Structured Programming			I,P,C		Y
Variable Types and Assignment		I,P,C	I,P,C	I,P,C	
Input / Output		I,P,C	I,P,C	I,P,C	Y
Flow of Control		I,P,C	I,P,C	I,P,C	Y
Functions			I,P,C	I	Y
Objects and Object-Oriented Programming			I,P,C	I	Y
Use of an IDE			I,P,C	I	Y
System Modeling				I,P,C	
Systems Testing		I,P		I,P,C	
SDLC	I	I,P		I,P,C	
Project Management		I,P		I,P,C	Y

Legend: I = Introduce, P = Practice, C = Create

DATABASE

Multiple courses have traditionally covered database and database modeling at our institution, with a required Database course introducing design, modeling, and implementation. The textbook for the Systems Analysis and Design course also briefly covers these topics. Our advisory board unanimously listed SQL as a required skill, so this was a subject area that we emphasize. Two tutorials were initially implemented to facilitate knowledge and ability in SQL and to better understand how data is stored.

Database design, ERDs, and Business Rules Tutorial

Objective: The objective of the Database Design, ERDs, and Business Rules Tutorial is to reinforce knowledge about the relationships of data so that a relational database may be designed to maximize data integrity and efficiency. By understanding key aspects of relational database design and applying them to the project, the students should improve their understanding of relational databases and be forced to think about how the data is connected critically.

Teaching Tips: ERDs should be complete with primary and foreign keys to connect the concepts to the SQL tutorial. It is unnecessary to cover the entire ERD but instead focus on the critical aspects of the ERD that the student or group is interested in for the project.

SQL (joins, unions, and case statements)

Objective: The objective of the SQL Tutorial is to reinforce knowledge of advanced SQL topics. Joins and Unions allow the integration of data. Case statements allow for data engineering data. Students should also implement other SQL aspects such as aggregate functions and views as appropriate to demonstrate critical thinking in the practical application of SQL.

Teaching Tips: The SQL tutorial should connect with the previous tutorial. There should be an emphasis on joining the tables in the previous tutorial, if possible, further reinforcing the connection between modeling and using the relational database. Additionally, if reports are a requirement of the project, the SQL statements should generate a report.

DATA COMMUNICATIONS AND NETWORKING

Networking skills were stressed by our industry advisors, with emphasis on information security and cloud computing. For cloud-based environments, it was essential to understand the system's requirements, the complexity of transitioning to the cloud, and the importance of service level agreements. With constraints on class size and time, the decision was made to create a single tutorial.

Networking: network diagrams, technology architecture diagrams, and service level agreements related to system requirements

Objective: The objective of the Networking Tutorial is to reinforce knowledge of how the various components of the information system connect. The concepts should be tied to meeting the performance, reliability, and security requirements of the information system; by diagramming the system and listing key service level agreements, a general understanding of the necessary components for delivering the final product of an Information System project should be demonstrated.

Teaching Tips: Connecting nonfunctional requirements such as reliability, performance, and security to the tutorial should be used to enforce the course's systems analysis and design concepts. Allowing and encouraging the evaluation of using either an in-house cloud or purchasing cloud services allows for critical thinking about the project needs, so the student or group should be made to answer what is needed and why they selected the components.

BUSINESS PROGRAMMING

Programming skills were emphasized by many on our advisory board, but this topic also had the most disagreement. Some felt that experience in a single programming language was sufficient, while others see the need for integrating multiple languages. Others put the emphasis on modeling the problem because they expect future information systems and analytics positions would be more about using software that allowed for "low code" or "no-code" solutions.

Structured programming (include the elementary control structures)

Objective: The objective of the Structured Programming Tutorial is to reinforce knowledge of the general structure of a programming language. The students should demonstrate knowledge that the general format of programming is logical and sequential, with loops and decisions altering the flow of the algorithm. Additionally, the students should also understand that programming may be modular by incorporating functions into the tutorial.

Teaching Tips: For our students, we were in transition on the programming languages taught, and some students were taking programming concurrently with the capstone course, forcing students with introductory knowledge of various languages to discuss which language to use for the project. The discussion on which language to use served as an opening to show the similarity of programming languages. It may be beneficial to show some code in multiple languages so that the entire class may benefit. The instructor should guide the student delivering the TB tutorial to use an example relevant to all groups, such as a general analytics procedure or another common function such as creating a user login module.

Object-Oriented Design – Design class diagrams for a use case

Objective: The objective of the Object-Oriented Design Tutorial is to reinforce the conceptual knowledge of object-oriented design. The students should be able to make a storyboard of an application and connect the classes sequentially for how they are used in the program. The student should also identify the attributes within each class and the functions or methods in each class.

Teaching Tips: This tutorial ideally should use concepts from the database tutorials and the structured programming tutorial. Classes and their attributes should follow a similar logic to the ERDs previously shown, which will hopefully lead to a discussion of using UML class diagrams versus ERDs in modeling information. Additionally, referring to functions created in previous tutorials also will allow for connecting concepts. Overlapping multiple concepts again demonstrates review and application that is key in a constructivist approach to pedagogy.

RESULTS AND DISCUSSION

Case studies require multiple forms of evidence to support their findings. We have presented some of them in Table 2.

First, while many factors may influence changes in results in cohorts, the overall scores rose from 66% in 2018 to 69% in 2019 to 71% in 2020. We observed initial increases of 10% and 3% in knowledge retention in the areas of networking and database, respectively, in 2019 with the scores remaining the same following the initial onset of the pandemic in 2020. While not as large, this is consistent with prior results when employing TB (Mahajan et al., 2020). Networking showing the most significant increase is consistent with the fact that the topic is covered in the fewest electives.

Table 2. Teach back evidence, results, and conclusions

Evidence	Observed results	Preliminary conclusions and implications
Capstone Exam Results	While many factors may influence changes in results in cohorts the overall scores rose from 66% in 2018 to 69% in 2019 to 71% in 2020.	The results indicate that tutorials may contribute to improved performance. However, many factors influence capstone scores including when and which electives may have been taken. The gap analysis does however ensure that more concepts have been reviewed in more than one course.
Course Evaluations	Remarks in course evaluations were mixed with some students commenting that it was a great experience and others complaining that students should not have to teach concepts to themselves. The negative comments primarily stemmed from implementation in online courses. A course that was forced to transition to online during the pandemic was still viewed favorably even with the implementation of an additional tutorial.	Students were positive about the experience in face-to-face courses, but implementation in traditional online courses has been challenging. Additional time needs to be spent to coordinate any group work. Courses that were interrupted by the pandemic saw reviews similar to face-to-face classes suggesting that it is a method that can be maintained during a sudden transition online.
Informal Student Feedback	Students noted free rider issues in some groups. Online students commented on the difficulty in coordinating times to meet with teammates and seemed to prefer videos created by the instructor. Face to face students indicated that they enjoyed working on tutorials and interacting with the instructor during parts of their class time.	Formal feedback through course evaluations and informal discussion with students were consistent. Teach back experience is more appreciated in face-to-face settings. In a face-to-face setting students preferred to cover some material through self-learning and reflection rather than traditional lecture, while online students desired more traditional material.
Alumni Comments	Students who have returned to campus to speak after having been in courses that utilized teach back have stressed the importance of soft skills and reported group work and teach back opportunities helped them to transition to the workplace. They stated that 80-90% of success depended on the ability to communicate and to gain or give accurate details including understanding the problem and its scope.	Teach back and other collaborative opportunities are appreciated more after exposure to the workplace. Having alumni speak may be a good way to reduce resistance to groupwork among students, and it supports the value of opportunities such as teach back to improve soft skills.
Instructor Observations	Performance and understanding improved the most on the subject that the students were assigned. Some students unless required to provide some immediate feedback did not give their full attention to their peers. Evaluating presentations before presented in class and then again during the formal presentation is time consuming. Selecting topics and assigning them to the appropriate students also takes careful consideration and time.	While instructors feel that teach back works, implementation is time consuming. It seems to be beneficial to assign students who are weaker on a subject that subject to teach, but this requires knowledge of the students and additional time in supporting the satisfactory completion of the assignment.
Employer Comments	The instructors have received unsolicited comments from employers commenting on the ability of students to adapt to new technology and work in a team environment.	This is consistent with prior cohorts so by implementing teach back we can't say that external approval has not improved, but it suggests that it has helped to keep students' soft skills sharp despite going through courses during the pandemic.

For programming, there was a 2% decline in the capstone scores in the first semester that tutorials were administered in 2019. However, it is essential to note that this initial decline occurred during a period of ongoing changes to the programming curriculum, and there was a rise of 20% in the tests administered during the spring semester of 2020 despite the onset of the pandemic and disruptions to classes. This variance may be partially explained by differences in the elective selections of students in each cohort causing various levels of programming experience. Students in our program may take electives after the capstone, so programming-related electives such as web development are often taken after the capstone course.

Students and employers have given us positive feedback on the soft skills that are learned throughout the program. Employers have observed that graduates can work in teams and communicate more effectively. This corroborates results from other implementations of TB (MacLean et al., 2018), justifying the extension of this concept into the field of Information Systems education.

Many students have also commented that the tutorials were helpful both on their projects and helping them connect concepts that they have learned in earlier courses. Houghton and Stewart (2017) replaced TL and phased out many lectures and instructor-led tutorials to add more active learning to their courses. However, feedback from our students was significant because it demonstrated that, while the role of TL can be reduced, students did have a continued need for tutorials linking concepts. However, there were some negative comments in traditional online courses due to a desire to have more instructor-created material and the feeling that the students were required to self-learn. This suggests that more research and consideration is needed in online implementation. However, courses that were transitioned online were viewed favorably indicating that emergency implementation is acceptable. The issue seems to be partially due to difficulties in coordinating meetings with online students. Therefore, some of the resistance may be handled in coordinating the formation of teams.

During a TB tutorial, the instructor can intervene promptly if a student errs in their presentation. While student presentations tend to mimic TL, instructors should encourage interactivity and interventions with correct information to get more value out of the TB concept. One goal of the interactions was to develop test questions to reinforce concepts where students had difficulty communicating or understanding. Instructors noted that unless this is stressed there is a tendency for other students to not fully engage with the presenter.

Fair warning before attempting to use the TB concept is warranted. TB takes more time commitment from both the instructor and the students than TL. Because of this, students can prefer a more conventional lecture approach even though grades were significantly higher using FTC (Tahir et al., 2020). This argues for informing students about the known benefits of TB before engaging in those activities.

LIMITATIONS AND FUTURE RESEARCH

The sections of courses in this study occurred during the COVID-19 pandemic. In particular, these students experienced isolation and remote learning during the early part of the pandemic. Overcoming learning gaps will continue to be an issue in capstone courses. But it is worth noting this unique aspect for these students.

As a single case study looking at a single university across three years, the results have limited generalizability. Additionally, as an intrinsic case, the results are subject to bias, although the researchers have taken measures to reduce this by drawing upon multiple sources, including supporting literature, documentation, and participant observation.

Because of the negative result in programming concepts, further research is needed to identify the TB concepts that will improve student performance in this area. Investigating the root cause of that deficiency led to a better understanding of why student performance in programming varied. There

was a secondary cause for knowledge gaps due to the timing of when students took the capstone course. Due to the timing and choice of electives, students may take some courses after or concurrent with the capstone. This can result in students having different levels of preparation for the capstone. Because of this, our department is re-evaluating the timing of both the capstone and our electives. What is the best timing for the capstone course relative to electives? In other words, should students be required to take the capstone in their final semester to ensure that they have the most comprehensive knowledge of the subject? Because information technology is constantly evolving, the curriculum content needs to be systematically revisited and assessed, therefore curriculum research and assessment research should be expanded upon.

There is the question of applying TB to the problem. Does the granularity of the tutorials or specific technology aid or hinder the learning outcome? What level of prior exposure is optimal before a student or group uses TB as a pedagogy? Can TB be implemented cost-effectively to supplement project-based courses? There is a need to study the long-term effects of faculty coordination in selecting the capstone projects and tutorial topics on student learning outcomes.

CONCLUSION

In this paper, the Teach Back method was introduced as a potential constructivist method for overcoming knowledge gaps. The case study was able to answer all three research questions:

1. Given the comprehensive nature of a capstone course, in which knowledge areas do our students have learning gaps?

Critical to our success was constructing a matrix of the skills required to complete the capstone project. We were then able to poll the students and faculty to quickly identify knowledge gaps. Having laid out the skills we wanted to cover we were also more readily able to adjust to needed changes in material covered by projects, such as those that were made necessary by the pandemic.

2. How can we address learning gaps that exist within students in the capstone course?

The Teach Back method proved to be very effective. Students were receptive to tutorials taught by their fellow students. The tutorial content showed that the students were "teaching back" the correct information. Those on the receiving end showed improvement in the tutorial knowledge areas evidenced by the increase in test scores. This continued despite the pandemic interrupting normal face-to-face course activities.

3. Can the learning gaps be addressed in such a way that it will improve the students' soft skills while reinforcing areas of knowledge weakness?

The student-to-student interaction required for this approach also had the benefit of improving students' soft skills. Presenting to peers in a group setting was a less intimidating way of practicing communication and presentation skills. While students still did not universally enjoy the experience alumni and employers seem to indicate that they value the experience that the students have teaching back material to their peers.

The past two years of the pandemic have had a significant impact on students and courses, resulting in knowledge gaps. Capstone courses are already challenging because students are expected to recall and use the knowledge acquired throughout all four years of their college program. Even under normal circumstances, students may enter the capstone with varying course backgrounds and retention and the evaluating gaps in learning helped to improve initial results. Our capstone exam results initially improved in the semester prior to the pandemic and then maintained or improved after the initial onset of the pandemic.

This research demonstrated that using the "Teach Back" method can help students fill in the gaps and reinforce learning from earlier in the program. Students showed overall improvement in scores

after TB was employed. While the scores still show areas for improvement, the resulting progress is sufficiently encouraging to warrant further development in the use of TB for the course.

REFERENCES

Balwant, P. T., & Doon, R. (2021). Alternatives to the conventional 'Oxford' tutorial model: A scoping review. *International Journal of Educational Technology in Higher Education*, *18*(1), 1-24. https://doi.org/10.1186/s41239-021-00265-y

Chis, A. E., Moldovan, A.-N., Murphy, L., Pathak, P., & Hava Muntean, C. (2018). Investigating flipped classroom and problem-based learning in a programming module for computing conversion course. *Journal of Educational Technology & Society*, *21*(4), 232-247. https://www.researchgate.net/publication/328929802_Investigating_Flipped_Classroom_and_Problem-based_Learning_in_a_programming_module_for_computing_conversion_course

Cristea, S. (2015). The fundaments of constructivist pedagogy. *Procedia – Social and Behavioral Sciences*, *180*, 759-764. https://doi.org/10.1016/j.sbspro.2015.02.197

Davenport, C. E. (2018). Evolution in student perceptions of a flipped classroom in a computer programming course. *Journal of College Science Teaching*, *47*(4), 30-35. https://doi.org/10.2505/4/jcst18_047_04_30

Hauhart, R. C., & Grahe, J. E. (2015). *Designing and teaching undergraduate capstone courses*. Jossey-Bass.

Houghton, L., & Stewart, H. (2017). Using the 'Engagement' model of problem solving to assist students in capstone learning. *Systemic Practice & Action Research*, *30*(5), 471-485. https://doi.org/10.1007/s11213-016-9405-4

Leedy, P. D. (1997). *Practical research planning and design* (6th ed.). Prentice-Hall.

MacLean, S., Kelly, M., Geddes, F., & Della, P. (2018). Evaluating the use of teach-back in simulation training to improve discharge communication practices of undergraduate nursing students. *Clinical Simulation in Nursing*, 22, 13–21. https://doi.org/10.1016/j.ecns.2018.06.005

Mahajan, M., Hogewoning, J.A., Zewald, J. J. A., Kerkmeer, M., Feitsma, M., & van Rijssel, D. (2020). The impact of teach-back on patient recall and understanding of discharge information in the emergency department: The Emergency Teach-Back (EM-TeBa) study. *International Journal of Emergency Medicine*, *13*(1), 1-8. https://doi.org/10.1186/s12245-020-00306-9

McNally, B., Chipperfield, J., Dorsett, P., Del Fabbro. L., Frommolt, V., Goetz, S., Lewohl, J., Molineux, M., Pearson, A., Reddan, G., Roiko, A., & Rung, A. (2017). Flipped classroom experiences: Student preferences and flip strategy in a higher education context. *Higher Education*, *73*(2), 281-298. https://doi.org/10.1007/s10734-016-0014-z

Melonçon, L., & Henschel, S. (2013). Current state of U.S. undergraduate degree programs in technical and professional communication. *Technical Communication*, *60*(1), 45-64. https://tek-ritr.com/wp-content/uploads/2015/07/undergrad_degrees.pdf

Melonçon, L., & Schreiber, J. (2018). Advocating for sustainability: A report on and critique of the undergraduate capstone course. *Technical Communication Quarterly*, *27*(4), 322-335. https://doi.org/10.1080/10572252.2018.1515407

Meyer, C. B. (2001). A case in case study methodology. *Field Methods*, *13*(4), 329-352. https://doi.org/10.1177/1525822X0101300402

National Research Council. (2011). *Assessing 21st century skills: Summary of a workshop*. The National Academies Press. https://doi.org/10.17226/13215

Roseler, K., Paul, C.A., Felton, M., & Theisen, C.H. (2018). Observable features of active science education practices. *Journal of College Science Teaching*, *47*(6), 83-91. https://doi.org/10.2505/4/jcst18_047_06_83

Sasipraba, T., Bantha Navas, R. K., Nandhitha, N. M., Prakash, S., Jayaprabakar, J., Pushpakala, S. P., Subbiah, G., Kavipriya, P., Ravi, T., & Arunkumar, G. (2020). Assessment tools and rubrics for evaluating the capstone projects in outcome based education. *Procedia Computer Science*, *172*, 296–301. https://doi.org/10.1016/j.procs.2020.05.047

Shake, E. E., & Lavin, J. (2018). Benefits, challenges, and solutions in educational-practice partnerships for students' capstone projects. *International Journal of Nursing Education*, *10*(1), 98-103. https://doi.org/10.5958/0974-9357.2018.00020.X

Tahir, F., Hafiz, B., Alnajjar, T., Almehmadi, B., Besharah, B., Gari, A., & Katib, Y. (2020). Comparison of performance of medical students between two teaching modalities "Flip the classroom" and traditional lectures: A single center educational interventional study. *Pakistan Journal of Medical Sciences*, *36*(5), 958-964. https://doi.org/10.12669/pjms.36.5.2730

Tellis, W. M. (1997). Application of a case study methodology. *The Qualitative Report*, *3*(3), 1-19. https://doi.org/10.46743/2160-3715/1997.2015

Utley, R. (2011). *Theory and research for academic nurse educators: Application to practice.* Jones and Bartlett Learning.

Ward, M., Knowlton, M. C., & Laney, C. W. (2018). The flip side of traditional nursing education: A literature review. *Nurse Education in Practice*, *29*, 163-171. https://doi.org/10.1016/j.nepr.2018.01.003

Wright, E. L., Sunal, D. W., & Day, J. B. (2004). Reform in undergraduate science classrooms. In D. W. Sunal, E. L. Wright, & J. Bland (Eds.), *Reform in undergraduate science teaching for the 21st century* (pp. 33-52). Information Age Publishing.

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