Issues in Informing Science + Information Technology

An Official Publication of the Informing Science Institute
InformingScience.org

IISIT.org

Volume 22, 2025

EMBEDDING INQUIRY-BASED LEARNING IN A LARGE DATABASE COURSE VIA PAIRED ASSESSMENT

Mali Senapathi — Auckland University of Technology, Auckland, New Zealand — mali.senapathi@aut.ac.nz

ABSTRACT

Aim/Purpose	Given the complex and ill-structured nature of modelling problems, database education can benefit from learning approaches such as inquiry-based learning (IBL), where students are encouraged to work collaboratively on modelling, design, and querying tasks. IBL can be embedded into teaching approaches such as pair programming, which is known for its many benefits, for example, improved student collaboration, enhanced student involvement, and deep learning.
Background	Data modelling, design, and SQL are crucial parts of a database course in computing, information systems (IS), IT, and software engineering curricula. Students must analyse and model activities at high levels of abstraction before moving to the design, implementation, and data manipulation phases. This research examines the impact of using IBL via a paired assessment in combination with existing teaching methods as an effective learning technique in the practical database project assessment.
Methodology	This study implements IBL via a paired assessment strategy in a large undergraduate Database System Design course. Students were assessed in pairs to see if they could effectively complete the assessment in collaboration with their partners. Qualitative data was collected and analysed to determine if the paired approach improved learning effectiveness and performance. Furthermore, student feedback and perceptions are analysed.
Contribution	This research enhances the literature on database education and IBL by presenting a paired assessment approach for academics interested in implementing this methodology in their database courses. It demonstrates how paired assessments can facilitate collaboration in database education. The study outlines four key lessons learned and provides guidelines for effectively assigning pairs, monitoring the balanced contributions of student pairs, implementing peer evaluation systems, and enforcing a strict policy on student attendance and engagement.

Editor: Eli Cohen | Received: December 13, 2025 | Revised: March 19, 2025 | Accepted: May 12, 2025
Cite as: Senapathi, M. (2025). Embedding inquiry-based learning in a large database course via paired assessment. *Issues in Informing Science and Information Technology, 22,* Article 11. https://doi.org/10.28945/5524

Findings	Findings related to student learning show that the paired assessment was an effective learning technique that improved student engagement and learning. Students strongly supported the paired assessment approach, and their overall perceptions were positive. The findings led to the identification of four lessons learned and guidelines for future implementation.
Recommendations for Practitioners	Educational implications emphasize the challenges of inquiry-based learning through paired learning for assessment, such as guidelines for assigning pairs and monitoring students' balanced contributions. They also highlight the benefits, including the development of soft skills.
Recommendations for Researchers	This study offers guidelines and recommendations for implementing IBL using paired assessment in database education. Researchers can explore the application of pair-based assessment in online and hybrid database education.
Impact on Society	Academic faculty that aims to enhance student learning in the complex and ill-structured nature of data modelling and database design, as well as in teamwork and collaboration, will benefit their students, the workforce, and society.
Future Research	Future research could adapt the proposed methodology in various contexts. Additionally, its impact on the online environment warrants further investigation.
Keywords	database education, paired assessment, paired learning, inquiry-based learning, collaborative learning

INTRODUCTION

Database systems are critical in developing and applying appropriate tools and technologies to solve industry problems. A lot of our technological infrastructure continues to rely on relational databases. Therefore, it is unsurprising that the database management course is a foundational element of contemporary computing programmes (Huang & Leng, 2019; Leidig & Salmela, 2021). For example, Database Systems is one of the six main subject areas in the undergraduate curriculum guidelines of contemporary disciplines such as Data Science (De Veaux et al., 2017).

Data modelling and design are vital to a database course in the information systems curricula. Students engage with the high-level abstraction and representation of data pertinent to a case study or an organisation (Bogdanova & Snoeck, 2019). It is one of the key concepts related to developing and applying data articulation skills required to make sound judgments with data. Learning data modelling is challenging for novice students because of the abstract and complex nature of the analysis, modelling, and design process (Katz, 2020). Students must grasp the ill-structured nature of modelling problems, the specifics of the problem domain, and the nuances of learning a specific data modelling methodology such as Entity Relationship (ER) modelling (Bock & Yager, 2005). Several teaching approaches and frameworks to support the effective delivery of database topics are proposed in the extant literature, such as the constructivist approach (Connolly & Begg, 2006), the learning-from-errors teaching approach (Bogdanova & Snoeck, 2018; Katz & Shmallo, 2016), and educational frameworks for conceptual data modelling (Bogdanova & Snoeck, 2019). Over the last two decades, pair programming has been an essential collaborative learning approach in many programming courses. Pair programming works effectively for several reasons (Williams & Kessler, 2000); it promotes collective ownership of the work produced, as both partners contribute to the outcome. Additionally, it keeps both individuals engaged and focused on the task at hand. Finally, pair programming helps improve each participant's skills through collaboration and knowledge sharing. Pair programming is recommended to be used even in non-programming courses (Gehringer, 2003). In computing courses,

paired learning approaches are used to prepare students to face the realities of software development in their future workplaces, where they will spend most of their time working with other analysts, developers, and designers (Hawlitschek et al., 2023). However, pairing students as an assessment approach to address the learning needs of students in database education has received very limited attention. Paired assessment refers to the integration of a paired learning approach within a significant summative assessment of the course, which contributes to the final grade needed to pass.

Inquiry-based learning (IBL) is a teaching method that involves students in problem-solving tasks. The core principle of IBL is to enhance retention by employing a teaching method that encourages students to construct their own understanding, engage in collaborative discussions, and ultimately achieve deep learning (Coleman & Nichols, 2011). It guides them through well-constructed problems, leading to an engaging adventure in discovering and applying concepts. These problems require students to explore, analyse, and resolve issues while creating design solutions (Love et al., 2015). In a database course, students are expected to perform tasks such as analysing the data requirements of a specific problem domain, creating data models and designs, and implementing databases. These activities align well with the principles of the IBL approach.

Given the complex and ill-structured nature of modelling problems, it would be beneficial to embed IBL in database courses via collaborative approaches such as paired learning. By introducing paired learning, students are encouraged to work together to discuss and solve problems. This hands-on approach to solving database tasks is aimed at enhancing their understanding of database modelling and design. It can help improve students' understanding of challenging database concepts and increase the quality of submitted assessments (Taipalus & Seppänen, 2020). This study aims to examine the impact of embedding IBL via a paired assessment in a large undergraduate Database System Design course to answer the following research questions:

RQ1: Is paired assessment effective in improving learning in a large introductory database course?

RQ2: What do students perceive about working in pairs?

This paper is organised as follows. The next section offers background information for this study and reviews relevant literature. The subsequent section details the research methodology, including specific information regarding the database course and the implementation of the paired assessment. This is followed by a presentation of the results and discussion. The final section outlines four key lessons learned and four practical guidelines derived from the study's findings, with particular emphasis on the implementation of paired assessments in database education.

BACKGROUND AND RELATED STUDIES

DATABASE EDUCATION

Database design and implementation comprise an integrated set of concepts that relate to analysis, modelling, design, implementation, and data manipulation. It is a required introductory course in many undergraduate programs in computing, IS, and IT disciplines, as it provides the foundation for database topics, such as querying, creating databases from a model, and managing databases using SQL (Wagner, 2005). Its significance is evident in its inclusion as a core module in the IEEE/ACM curricula for degree programs in Computer Science, Information Technology, Information Systems, and Data Science (ACM Data Science Task Force, 2021; CC2020 Task Force, 2020; Topi et al., 2010). These curriculum guidelines recommend that the foundation undergraduate courses in database design must include, among other topics, conceptual and logical database design (including the relational model, logical data modelling and normalisation) and SQL. The learning tasks in these topics have a level of interdependent concepts. For example, students must achieve a good understanding of conceptual modelling before learning logical database design. Similarly, they must understand the relational model concepts before learning logical database design and so on. Understanding these interrelated abstract concepts presents one of the main challenges for novice database learners (Katz

& Shmallo, 2016). Furthermore, developing conceptual and logical models involves working with unstructured problems that require students to deal with concepts of a high level of abstraction.

As discussed above, the dependencies between the various topics and concepts in a database course can present challenges for novice student learners, diminishing their interest and enthusiasm for the subject (Huang & Leng, 2019; Senapathi, 2004). Hands-on learning is the preferred method for students studying database systems as it fosters greater interest in the subject, encourages peer communication, and inspires further exploration of related topics after graduation (Ramakrishna, 2000). Furthermore, research suggests that students studying database systems need to grasp not only the fundamental concepts and theoretical knowledge of databases but also how to apply this understanding to real-world database implementation (Huang & Leng, 2019). Therefore, integrating a solid conceptual and theoretical foundation with practical implementation would be an effective approach to developing the knowledge and skills of novice learners in database technology (Mitchell & Vaughan, 2022). Based on established principles of effective teaching and learning in database management, this area offers a promising opportunity for implementing a collaborative pair-learning approach. (Mitchell & Vaughan, 2022).

Collaborative and Pair-learning

Cooperative learning highlights the social aspect of cognitive development, emphasising the importance of social interaction and collaboration in the learning process (Vygotsky, 1978). Vygotsky's theory suggests that students develop cognitively when they work within their Zone of Proximal Development (ZPD). The ZPD refers to the range of tasks that a learner can accomplish with help from a More Knowledgeable Other (MKO) rather than alone. An MKO can be a mentor, peer, or an individual with greater knowledge or skills related to a specific task or concept (Demir & Seferoglu, 2021; Vygotsky, 1978). Vygotsky asserted that students cannot achieve reach the same level of understanding when working independently.

Collaborative learning is characterized by a distribution of tasks among the participants, where each student works on their respective tasks, which are combined and reviewed together at specific times/phases to achieve desired outcomes (Hawlitschek et al., 2023). It positively impacts academic performance for students who struggle to cope with the technical aspects of computing courses (Van Der Vyver & Lane, 2003). Studies in computing education have shown that collaborative learning (e.g., team-based learning, pair programming) leads to greater learner engagement, understanding, and problem-solving, making students less frustrated, more confident, and more motivated (Mitchell & Vaughan, 2022). These benefits may help in increasing the retention rate of students enrolled in computing programmes.

Pair programming or pair learning is a collaborative learning approach. Though pair programming was practised before 2000, it became widely popular when it included eXtreme Programming (Beck, 2000; Salge & Berente, 2016) as a fundamental practice of the Agile method. The reported positive benefits of pair programming include the development of collaborative teamwork skills, improved performance, improved quality of submitted assessments, and increased confidence, comprehension, and learning (Dybå et al., 2007; Hawlitschek et al., 2023; Salge & Berente, 2016; Salleh et al., 2014; Umapathy & Ritzhaupt, 2017). Disadvantages such as team or pair incompatibility (McDowell et al., 2003) and unequal participation have also been reported (Thomas et al., 2003). Assessments based on collaborative approaches also offer many benefits to the teaching staff, such as reduced grading time and less time in dealing with student queries, as students often solve the issues themselves (Williams et al., 2008).

Extant research in database education has mainly focused on course design and delivery (Wang & Ma, 2017), pedagogical tools for data modelling (Mitrovic & Suraweera, 2016), and issues related to teaching database design to novice learners (Bogdanova & Snoeck, 2018). There is minimal research on implementing specific collaborative learning approaches in database assessment tasks. While approaches such as pair programming have been extensively studied within a software development

context, pairing students as a learning approach has not received attention in database education. A few exceptions include a study that introduced two cooperative learning methods – paired thinking and cooperative groups – which were reported to foster positive learning attitudes among students, although the impact of these approaches was not empirically evaluated (Brown & Klein, 2003). A more recent study explored using a collaborative learning mechanism known as think-pair-share in an introductory database course (Catania et al., 2022). The approach was implemented during lectures, lab sessions, and peer review of team projects to assess the effectiveness of collaborative learning techniques in this subject. The study included both a control group and a test group, with the control group not engaging in the pair-learning activities. The results indicated that students who participated in the pair-learning collaborative activities exhibited more consistent outcomes compared to those who passed the course without participating.

INQUIRY-BASED LEARNING

Two common approaches used in database education are problem-based learning and project-based learning (PBL), grounded in the constructivist approach to learning (Connolly & Begg, 2006). In problem-based learning, the focus is on students solving a specific problem in a given context (Gordon & Brayshaw, 2008). It often involves collaborative learning activities, which help students develop essential analysis and problem-solving skills, recognised as essential learning outcomes. PBL is similar to problem-based learning, where the students work collaboratively to complete a project by identifying and solving several problems and tasks. Inquiry-based learning shares many characteristics with the two learning approaches mentioned above (Gordon & Brayshaw, 2008). In IBL, students are typically presented with a project or assignment and must discover for themselves – with tutor facilitation – and identify the learning needs and the skills they may need to complete the project (Gordon & Brayshaw, 2008). There are two fundamental elements of IBL – deep engagement and opportunities for collaboration (Love et al., 2015). It has many benefits, such as increasing student involvement, encouraging collaboration among students, and developing deeper knowledge due to the students' thinking through the processes themselves (Prince & Felder, 2007). Students engage in self-thinking and reflection, as well as in the process of exploring and learning, raising questions, planning and executing learning tasks, and communicating with teaching staff and peers, ultimately fostering deep learning (Coleman & Nichols, 2011).

Embedding IBL in a database course allows students to collaborate by deeply engaging in database modelling, design, and data manipulation tasks. One interesting approach to assessments based on paired learning would be to pair students where both partners engage in complex tasks such as data modelling that would be difficult to do individually, thus supporting each other's skills. This paper presents the implementation of a paired assessment designed to integrate the crossway competencies of paired students with the longitudinal development of modelling, design, and implementation skills. Consideration was given to the potential costs associated with implementing paired assessments. While some students may be motivated to contribute conscientiously, recognising that inadequate participation could negatively affect their partner's grade, a subset of students demonstrate a preference for individual work.

METHODOLOGY: PAIRED ASSESSMENT IN A DATABASE COURSE

The database course is mandatory in the first year of the three-year undergraduate computing and information science programme at Auckland University of Technology, New Zealand. The programme's graduate profile requires the database course to be included as the core for all students, irrespective of the major being followed. The course is also taken by students in the software engineering major of the university's four-year undergraduate engineering programme in their second year. The course intends to impart an in-depth understanding of data modelling and database design and implementation concepts and provide students with the skills to model, implement, and query a relational database system. The paired assessment was developed following a major restructuring of the

new computing degree, first launched in Semester 2 (S2), 2021. The curriculum was updated to ensure it aligns with the latest advancements in the software and information technology sector, as well as the evolving expectations of employers. The student enrollment numbers nearly doubled from S2, 2022, compared to earlier terms. For instance, the total number of enrollments in the database course increased from 151 in S1, 2022, to 296 in S2, 2022, and this upward trend has continued ever since. This study outlines the paired assessment implemented in the course over two semesters in 2024. It aims to evaluate the effectiveness of paired learning in enhancing student learning and engagement while also highlighting student perceptions regarding the effectiveness of this paired approach.

Course Structure and Research Setting

The course content is made up of three main parts: (1) fundamental concepts of database systems, (2) conceptual and logical data modelling using Visual Paradigm, and (3) implementing a relational database and constructing queries (SQL) using Oracle database.

Each semester, students were divided into 6 or 7 laboratory sections based on the number of enrolments. The resources for the course were once the course leader (a senior academic staff) and five teaching assistants. The course consisted of twelve weekly two-hour lectures and two-hour laboratory sessions. The course design used a spiral approach in which the concepts of relational data modelling and SQL teaching were integrated to enable students to understand the link between what they model and how they query and create such models (Watson, 2006). For example, when relational joins were covered in the lecture, querying multiple tables using SQL joins was covered in parallel in the lab sessions. The weekly formative lab tasks were designed and structured to align with the concepts taught in the lecture and the summative assessment tasks and phases. For example, when the topic of business rules was covered in the lecture, students had to complete exercises on developing business rules and start working in their paired groups on their DB project Phase 1, Task 1 (see subsection below). The weekly 2-hour lab sessions were guaranteed time for students to work together.

The summative assessments for the course consisted of three components: (1) lab portfolio (20%) – four SQL quizzes (one each in weeks three, five, seven, and eleven); (2) midterm assessment in week 8 (30%); and (3) database project (50%) in two formative phases designed to reflect the stages involved in database development, including the development of conceptual and logical modelling, database design and implementation.

Database Project Paired Assessment

The paired assessment was designed for the third assessment component, Database Project (50%), replacing an individual assignment of the same weight from previous semesters that did not require implementing a complete database. The database project had two major phases. In the first phase, students had to (i) analyse and develop a set of business rules for a specific case study and (ii) develop a conceptual model. In the second phase, students had to (i) develop a logical data model and (ii) implement a relational database using Oracle.

First, students were provided with a brief description of the benefits of working in pairs. Students were informed that it was intended for them to collaborate with each other and learn to work together. They were asked to find partners from their laboratory section in the first week of the semester. A clear set of instructions on joining a group in Canvas was provided at the beginning of the semester. Canvas (https://www.instructure.com/canvas) is the university's learning management system that academic staff use to make teaching and learning resources available to students, communicate with the entire class, and allow students to collaborate with each other through various communication and messaging tools. A forum was set up in Canvas where students could advertise to find a partner by providing details such as their section, preferences, and other information relevant to working together. Given the large class size, the teaching team had to assist students who struggled to find partners within their sections. Students who wanted to work individually had to email the course leader for approval. In Semester 1 of 2024, 228 students chose to work in pairs through

Canvas, while 50 opted to work solo. In Semester 2 of 2024, 232 students paired up, and 35 decided to work individually. The goal was to provide students with the opportunity to learn together, share knowledge, and also allow those who preferred to work alone to do so. At first, there were issues with students joining groups without confirming whether their potential partners were willing to work together. The course leader addressed these issues during the lecture and through weekly updates on Canvas, such as, "*You must join a group only after you have met and agreed with your partner to work together."*

In their weekly lab sessions, students worked in rooms where the desks were arranged for pairs to sit next to each other, each at a computer. Although the paired approach was specifically for the Database project assessment, students were encouraged to collaborate on their weekly lab tasks and the project together. The regularly scheduled lab times facilitated opportunities for students to meet and work on their database project assessment tasks.

The paired assessment tasks required each student to contribute to developing conceptual and logical models, database design, and implementation. Students were provided the assessment details to clarify the task requirements' goals and criteria for different achievement levels. However, some criteria for modelling tasks, such as identifying entities and relationships, were complex and difficult to formulate. One key principle of inquiry-based learning (IBL) is that tutor facilitation and feedback practices help students identify their learning needs and assess their progress toward achieving the learning goals necessary to complete the assessment (Nicol & Macfarlane-Dick, 2006). There must be a realistic degree of overlap between the students' understanding of goals and the goals set by the teacher. Providing students with 'exemplars of performance' has proved to be a particularly effective approach in clarifying goals because they make explicit what is required and offer a good standard against which students can evaluate their work (Orsmond et al., 2002). After completing Phase 1, students were provided with an 'exemplar of performance' for Task 1 as a form of feedback (see Phase 2 below). Additionally, a session was scheduled to discuss and clarify any questions regarding the database project up to that point.

The paired assessment had five tasks that students had to complete in two phases. A high-level description of the tasks is described below:

Phase 1: Phase 1 involved two formative tasks – analysing requirements and developing a conceptual entity relationship diagram (ERD).

Task 1: Analyse requirements and develop a set of business rules.

Task 2: Based on the business rules developed in Task 1, create a conceptual ERD.

Phase 2: After students submitted Phase 1 tasks, they were given a suggested set of business rules for Task 1 as an 'exemplar of performance' to compare and evaluate their work before proceeding to Phase 2, which had three tasks. Students were asked to compare and evaluate their answers to Task 1 and Task 2 with the suggested business rules and make necessary changes before developing their logical ERD in Task 3, which is listed below.

Task 3: Use the suggested business rules to develop your logical ERD in Part B.

- Evaluate your work on Tasks 1 and 2 based on the suggested model answers provided
- List all the changes made to your ERD in a table. Include also the changes made in response to the feedback you received on your Part A submission.
- Apply the mapping rules to transform your conceptual ERD into a logical ERD (i.e., ER diagrams to relations).

This way, feedback was integrated into the assignment through initial phases and tasks so that the students understood the initial tasks before making productive improvements in the subsequent phases. To enhance understanding of feedback and enable students to correct misunderstandings, peer dialogue and feedback strategies were employed, which have proven effective in promoting self-

regulated learning among students (Nicol & Macfarlane-Dick, 2006). The teaching team used a dialogical feedback strategy in the laboratory sessions, asking students to review the 'exemplar' and feedback given earlier on the assignment tasks and discuss it with their paired partner. In particular, students were asked to (i) review and discuss both the suggested model answers and comments given earlier on task 1 and to suggest strategies to improve performance; (ii) find one or two specific feedback comments that they found helpful and to explain why and how they helped; and (iii) discuss goals and criteria of each phase before moving to tasks in subsequent phases.

On completion of Task 3, the assessment required students to divide the entities in their logical ERD between the two members of each paired group. The pair had to ensure each person had both parent and child tables to work with.

Tasks 4 and 5 related to creating the database using Oracle. Though the tasks were divided, the paired students had to collaborate, as they would need to grant privileges to access each other's tables and finally submit all tasks as a paired group.

> *Task 4*: Create the tables in Oracle: Students must create only the tables assigned to them as per the division in Task 3 above.
>
> *Task 5:* Populate data: Insert a small sample of realistic test data (5-10 rows min.) into each table. Students must insert data only to the tables they created in Task 4.

PEER EVALUATION

- All paired students were asked to rate their own performance confidentially and that of their teammates in fulfilling paired responsibilities. This evaluation was conducted using the peer rating system developed by Kaufman et al. (1999). Peer evaluation ratings and feedback were collected through an online survey created in Qualtrics. The survey asked students to choose one of the nine ratings below to rate the degree to which the student and their partner fulfilled the assignment's responsibilities. Numerical values were assigned to each rating below from "1 - Excellent = 100" to "9 – No show" in 12.5 decrements.
  - 1 - Excellent (100): Consistently went above and beyond - carried more than the fair share of the load
  - 2 - Very good (87.5): Consistently did what they were supposed to do, very well prepared and cooperative
  - 3 - Satisfactory (75): Usually did what they were supposed to do, acceptably prepared and cooperative
  - 4 - Ordinary (62.5): Often did what they were supposed to do, minimally prepared and cooperative
  - 5 - Marginal (50): Sometimes failed to show up or complete tasks, rarely prepared
  - 6 - Deficient (37.5): Often failed to show up or complete assignments, rarely prepared
  - 7 - Unsatisfactory (25): Consistently failed to complete tasks, unprepared
  - 8 - Superficial (12.5): Practically no participation
  - 9 - No show (0): No participation at all

The peer evaluation form was available on Canvas during week 3 of the semester. It was explained and discussed with the students in class, and they completed it at the end of the semester. If any ratings were higher than "satisfactory," they would be used to adjust their average database assessment project grade. In the final week of the semester, after the last submission due date, the grades of students who received ratings between 4 and 9 from their peers were calculated. This was done using a weighting factor, determined by dividing each student's average rating by the pair average. The student's final grade was then calculated by multiplying the weighting factor by the paired project grade. A maximum weighting factor of 1.10 was enforced, and any calculated factors exceeding this value were scaled down.

DATA COLLECTION

As discussed earlier, students were briefed on the rationale behind adopting paired assessment and expectations such as task contributions, taking initiative, responsibility, and commitment during the first two weeks of the semester. The first two questions in the peer evaluation survey asked students to choose one of the nine ratings below to rate the degree to which the student and their partner fulfilled the assignment's responsibilities. Students were instructed to base their rating on their partner's participation, effort, and sense of responsibility rather than their academic ability.

1. Please indicate how *your partner* fulfilled their responsibilities in completing the Database Project tasks. Please choose a numerical rating (1 to 9) from the following possible ratings.
2. Please indicate how *you* fulfilled your responsibilities in completing the Database Project tasks. Please choose a numerical rating (1 to 9) from the following possible ratings.

The remaining five open-ended questions (adapted from Cliburn (2003)) asked students to reflect on their experience working in a paired group and overall comments or suggestions about the project.

3. Did you like working in pairs on the project? If not, why?
4. Did you think working with a partner was beneficial for you? Explain how?
5. Did you feel that the experience of paired work made you better at working with others? Explain how?
6. What would you have done differently, given the opportunity?
7. Do you have any other comments or suggestions about the project?

The data collected from the student grades in the database project assessment and the peer evaluation survey were used to analyse the results and findings, which are discussed next.

RESULTS AND FINDINGS

GRADE COMPARISON BETWEEN PAIRED AND SOLO STUDENTS

Based on the experience piloting the paired assessment in the previous two semesters and considering the large class size, the students were offered the option to work either with a partner or independently. In Semester 1, 228 students chose to work in pairs, while 50 opted to work solo. In Semester 2, 232 students paired up, and 35 decided to work individually. To address the first research question – *whether the paired assessment was effective in improving student learning and performance in a large undergraduate database course* – the database project grades of students who worked in pairs were compared with those who worked individually.

In S1, 2024, the grades of paired students were higher than the solo grades at all levels (Figure 1): A and B grades were higher, while C and D grades were lower for paired students. Though there were no major differences in grades between paired and solo students in S2, 2024, like S1, 2024, the A grades in S2, 2024 were higher for both paired and solo students. In S2, the B grades were higher for both paired and solo students than in S1, 2024. One possible explanation for better performance by solo students is that they understood the consequences of completing all the tasks independently, as it was clearly stated that there would be no reduction in assessment tasks for opting to do it individually. As a result, they felt a sense of responsibility and were committed to completing the assessment tasks effectively. Overall, qualitative evidence from the survey indicates that most paired students enjoyed working in pairs, which positively impacted their learning and performance.

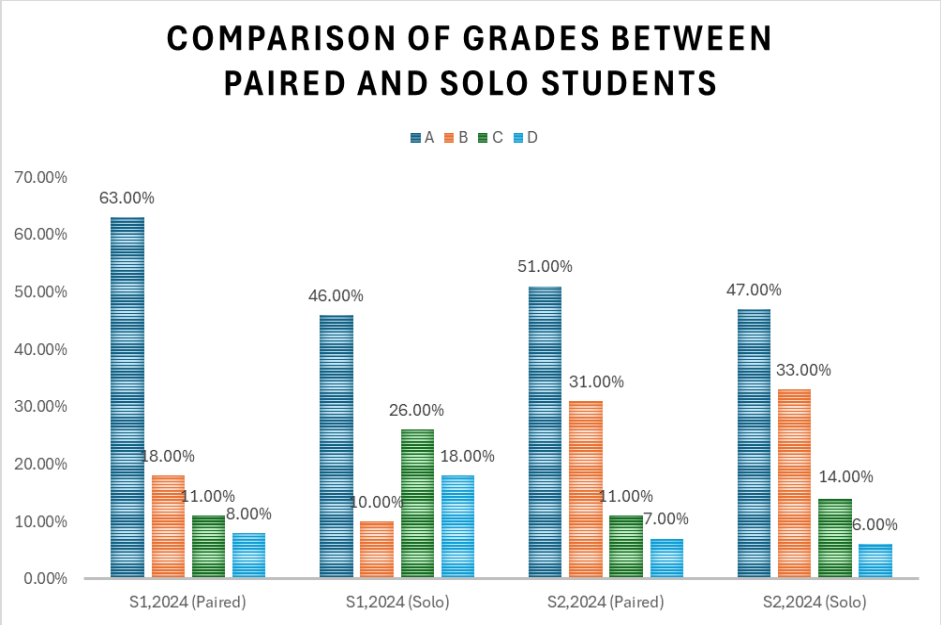

Figure 1. Overall grades in the Paired Assessment Project in Semesters 1 and 2, 2024

Table 1 shows the breakdown of grades for paired and solo students. Each grade level includes three sub-levels – see grade values.

Table 1. Grade range and values

Grade	S1,2024 (Paired) N = 228	S1,2024 (Solo) N = 50	S2,2024 (Paired) N = 232	S2,2024 (Solo) N = 35
A range (A+, A, A-)	**A total: 63%;** 'A+' = 36% 'A' = 16% 'A-' = 11%	**A total: 46%;** 'A+' = 28% 'A' = 8% 'A-' = 10%	**A total: 51%;** 'A+' = 22% 'A' = 10% 'A-' = 19%	**A total: 47%;** 'A+' = 27% 'A' = 14% 'A-' = 6%
B range (B+, B, B-)	**B total: 18%;** 'B+' = 7% 'B' = 7% 'B-' = 4%	**B total: 10%;** 'B+' = 6% 'B' = 2% 'B-' = 2%	**B total: 31%;** 'B+' = 17% 'B' = 8% 'B-' = 6%	**B total: 33%;** 'B+' = 14% 'B' = 13% 'B-' = 6%
C range (C+, C, C-)	**C total: 11%;** 'C+' = 4% 'C' = 1% 'C-' = 6%	**C total: 26%;** 'C+' = 18% 'C' = 6% 'C-' = 2%	**C total: 11%;** 'C+' = 3% 'C' = 5% 'C-' = 3%	**C total: 14%;** 'C+' = 2% 'C' = 6% 'C-' = 6%
D (below C-)	D: 8%	D: 18%	D: 7%	D: 6%
Grade values: **A range: >89.5, A+, >84.5, A, >79.5, A-** **B range: >74.5, B+, >69.5, B, >64.5, B-** **C range: >59.5, C+, >54.5, C, >49.5, C-** **D: < 49.5, "D";** **N: Number of students**				

Student Perceptions of Working in Pairs

To address the second research question, "What do students perceive about working in pairs?" data for each of the seven questions outlined in the Data Collection section were analysed. Despite reminders to complete the survey, not all paired students submitted their evaluations by the required

deadline, which was the same date as the database project assessment. In Semester 1 (S1) of 2024, 200 out of 228 paired students completed the peer evaluation survey. In Semester 2 (S2) of 2024, 227 out of 232 paired students participated in the survey.

Questions 1 and 2:

Their responses to the first two questions, which asked them to rate how well their partner and how well they themselves fulfilled their responsibilities in completing the Database Project tasks (on a scale from 1 to 9), are summarised in Table 2. As seen in Table 2, students rated themselves higher than their partners rated them, particularly for the values 'Very Good' and 'Satisfactory'. There were no self-ratings for the values ranging from 6 to 9.

Table 2. Grade range and values

	Semester 1, 2024		Semester 2, 2024	
Rating values	**Student rating of their partner**	**Student self-rating**	**Student rating of their partner**	**Student self-rating**
1 - Excellent	118	107	114	108
2 - Very good	40	61	65	87
3 - Satisfactory	15	29	22	27
4 - Ordinary	9	2	11	3
5 - Marginal	6	1	1	2
6 - Deficient	5	0	5	0
7 -Unsatisfactory	4	0	3	0
8 - Superficial	3	0	3	0
9 - No show	0	0	3	0
Total	200	200	227	227

The course leader assigned individual grades to all students whose peer ratings ranged from 3 to 9. These grades were calculated using a weighted factor, as explained in the Peer Evaluation section. Although there were no complaints regarding the peer rating system or their grades, the course leader met with a few students who had made minimal or unequal contributions to explain the rationale for the differences in their grades.

Question 3: Did you like working in pairs on the project? If not, why?

Most students strongly endorsed the benefits of working in pairs. The key concepts/themes identified from the analysis are presented below, along with example comments to illustrate each:

- Fun and enjoyment in the learning
  "*Yes, I enjoyed working in pairs, learned a lot"*
  "as it allows for collaboration, shared responsibility, and the opportunity to learn from one another"
  "it was fun"
- Relevance to workplace
  "because it is similar to work in real life"
- Division of workload
  "*ensures it is easier to divide the workload"*
  "better than working with a larger group"
  "it was easier to remain in contact with one person rather than trying to keep track of multiple people"

- Validation of tasks

  "if we make mistakes, we can correct each other"

  "*having others' input to help broaden my perspective and to point out where I may have missed details"*

  "good for error checking and back and forth corrections"

- Complementing skills

  "*because we both had areas we were good in and not good in … we could work together well and pick up on the areas where either one wasn't confident in"*

  "*beneficial because there were some areas of database systems that I was not very knowledgeable in, working together allowed share what we had learnt and to learn from each other"*

The following issues were noted by those who disliked working in pairs:

- Lack of understanding of the paired assessment guidelines

  "*my partner was not understanding the assignment criteria"*

  "not following the paired assessment guidelines"

  "they clearly did not use class notes"

- Lack of communication

  "when a person has a lack of communication, there is no partnership in the project"

- Working with a partner who lacked responsibility and commitment

  "*my peer was not responsible"*

  "my partner consistently fell through on their promises and self-imposed deadlines then failed to communicate this"

  "I get the driver/navigator concept but my partner just did not seem very eager to make an effort for the project. As much as I wanted to do well in this project, having an uninterested partner made it impossible."

- Finding additional times outside weekly lab sessions

  "the schedule conflict makes it difficult to work on the project together"

Question 4: Did you think working with a partner was beneficial for you? Explain how?

The responses to this question were similar to those for Question 3 and included comments on how working in pairs benefited them. The examples provided below include concepts not already identified in Question 3. Positive outcomes included,

- Improvement of specific skills

  "I think it really helped me improve my communication skills and helped me become more vocal and helped me voice my thoughts more clearly. I think that the support and motivation to push each other to be better really helped me excel."

  "I learnt a lot about SQL"

  "improved my soft skills"

  "improved my time management skills"

- Fostering empathy towards others

  "help me understand that different people have different deadlines and schedules to work around"

  "it made me more open to listening to what others have to say"

  "compromise when necessary, and appreciate different working styles. I learned to provide constructive feedback and to be more open to receiving it"

- Teaching accountability

  "*it kept me accountable for staying on schedule"*

  "because it teaches you to work collaboratively and develop a sense of responsibility"

  "it encouraged me to keep up to date, and reach out and communicate more towards my partner"

  "we both felt accountable to each other"

- Improved outcomes (e.g. quality of work, performance - higher grades)

  "It allowed for a diversity of perspectives and ideas, which led to more comprehensive solutions and better outcomes"

  "having a partner helped both of us to achieve higher marks as we compensated for the other person's shortcomings"

As the question asked students about the benefits of working with a partner, there were no specific comments regarding any drawbacks.

Question 5: Did you feel that the experience of paired work made you better at working with others? Explain how?

Students noted that collaborating in pairs enhanced their teamwork and social skills and facilitated the development of new abilities, as reflected in the comments below.

> "*of course, working with a partner gave me the opportunity to face my shyness"*
>
> *"made me more open to listening to what others have to say"*
>
> *"it worked to better my social skills in group work environments"*
>
> *"it showed me how difficult paired work can be, and how valuable good communication is"*
>
> *"improved my collaboration skills. It taught me how to communicate more effectively, compromise when necessary, and appreciate different working styles. I learned to provide constructive feedback and to be more open to receiving it"*

Very few negative experiences related to the concerns previously identified in Question 3, such as a preference for working alone, having an unreliable partner, and difficulty scheduling meeting times outside the weekly lab sessions, were reported.

Question 6: What would you have done differently, given the opportunity?

While most students said they would not have done anything significantly different, some noted they would have focused on improving the following areas:

- Understanding of the content and requirements:

  "understand the lecture content in more depth"

  "I would like to spend more time on this subject as I underestimated the topic"

  "ensuring that both partners have a shared understanding of the goals and responsibilities"

- Time management, communication, and improved planning:

  "I would allocate more time for planning and organising our work"

  "schedule regular meetings outside the lab to ensure that the project stays on schedule"

  "dedicated more time to planning and communication with my partner for a smoother workflow and better integration of ideas"

  "communicated more effectively"

  "better time management"

A few students commented:

> that they would pair with a better partner, *"finding a group member who was more knowledgeable and interested in perfecting a database rather than aiming for a mediocre grade*"
>
> would have worked individually *"worked on it by myself*"
>
> while a few others preferred *"groups of three rather than pairs"*

Question 7: Do you have any other comments or suggestions about the project?

Question 7 asked students for general comments or suggestions for improvements regarding the project rather than focusing on the paired assessment or learning. Students commented that the project helped them apply their learning to the different phases of database design and implementation,

> *"the project was really good, and it tested our understanding of the content we learnt in our labs and in the lectures"* and "*it was awesome really felt like work*!"

Another useful suggestion was to use GitHub for logging and tracking progress,

> *"It would be awesome if we could log our progress from each side, as developers create commits in GitHub, we will create a table when all the history of our work will be saved. I believe it will be perfect if the university has requirements on which tools we need to use for saving all files of our project, and the teacher can follow the history of creating the project."*

DISCUSSION

This study addresses two research questions:

RQ1: Is paired assessment effective in improving learning in a large introductory database course?

RQ2: What do students perceive about working in pairs?

Based on the results of the database project assessment and the qualitative data of student perceptions of paired learning, the paired approach was effective in improving learning. Overall, student perceptions of working in pairs were positive. As discussed in the Results and Findings section, most students strongly endorsed the many benefits of the paired assessment approach.

During the weekly lab sessions, the teaching team observed variations in collaboration quality among paired students. Some pairs worked effectively together, while others faced challenges. Students who took responsibility and relied on each other to complete the assessment tasks collaborated well and functioned as instructed. For example, stronger students listened to analysis and modelling ideas that differed from their own. On the contrary, weaker students benefited from sharing their ideas with their partners and tried to learn from them.

In a few cases, some students did not attend the lab sessions, leaving their partner to do a large amount of the assessment work, as illustrated by this student's feedback:

> "*Having a partner felt more like they were in the way, and the person I was paired with didn't do much of the work. I did the majority of the project, and I felt like I didn't get much support or effort put into the project from their end, so in the end, it felt like I could've done it without someone else.*"

As students submitted their peer evaluations only by the end of the submission date, resolving issues related to unequal contributions during the assessment was difficult. Some paired students did not complete the peer evaluation survey, possibly because it was not included in the assessment grade. Furthermore, attendance was not mandatory for the labs, and no penalty was built into the grading criteria. Students were given the option to work solo on the project. When students complained about their partners' issues, such as their partner's absence from the lab sessions and non-participation, the course leader dealt with such matters on a pair-by-pair basis.

LESSONS LEARNED AND GUIDELINES

Guidelines and lessons learned are presented based on the implementation experience and student feedback gathered during the deployment of the paired assessment in the database course.

ASSIGNING PAIRS

Due to the large class size, students were instructed to select partners from their respective laboratory sections and to work on the assessment tasks during the weekly laboratory sessions. Most students found partners within their lab sections. However, those who did not adhere to instructions struggled to secure a partner until week 3. A forum was set up on Canvas for students to advertise and find a partner. Some students expressed that they preferred the teachers "*should have organised us getting our partners*" while others felt "*overall it was a good thing, as it forced me to actually go out of my way find a partner, rather than they choose for me.*"

A few students felt forced to be in pairs, "*It was an absolutely terrible decision to force students to pair up for this assessment; it led to me being extremely stressed.*"

Guideline 1

Teachers should maximise opportunities for students to work effectively as a pair. They should foster understanding in the pairing process by recognising students' different preferences for pairing. Teachers should facilitate discussions to help align their perspectives with the students to develop effective and equitable collaborations among students (Graßl & Fraser, 2024). Teachers can use pair evaluation systems to pair students based on compatibility information such as personality types, experience, and partner preferences. For larger classes such as ours, where it was difficult for teachers to assign pairs, students should be given a choice to work with a partner or individually. With such an option, students who prefer to do the assessment individually will not feel pressured or forced to work in pairs. Students who prefer to work solo must notify the teachers of their choice by a specific date in the first week of class. The teaching team must monitor the paired groups' activities from the initial stages and provide timely and effective feedback.

BALANCED CONTRIBUTION OF PAIRED STUDENTS

Student pairs were formed within each lab section so that the corresponding teaching staff could monitor the progress of each partner and report issues associated with any pairs. As the student pairs worked on the lab tasks and the DB project assessment in the two-hour weekly lab sessions, there was not enough time to complete the assessment tasks, so students needed to work outside the scheduled lab sessions.

The feedback sessions on the initial tasks ensured that each student contributed to the analysis and development of data models as described in Phases 1 and 2. Though the requirements of tasks 4 and 5 asked students to divide the tasks between them, they were still required to collaborate and complete the assessment as a pair. While most students felt they contributed equally to the paired tasks, some felt their work was not balanced, and they contributed more, and few suggested having "*pre-partitioned tasks for each group member and being marked on the tasks that they have completed; this gives some accountability and still requires collaboration."*

Guideline 2

It is vital to ensure that individual students contribute equally to the learning tasks and do not rely solely on their partners. Effective feedback strategies support the student's efforts and contributions to the paired assessment. Instructors must use teacher and peer dialogue techniques to increase students' understanding of feedback by allowing them to clarify partner roles and issues and correct misunderstandings. Teachers must use a peer evaluation and rating mechanism to assess individual students' performance and adjust each member's pair grade based on their average ratings (discussed

next). Peer evaluations are critical when students must do paired work outside of regular laboratory sessions.

PEER EVALUATION

In the course, students were informed that peer evaluation ratings would be used to adjust individual grades in cases of underperformance within a pair. Though there were no significant issues regarding unequal student contributions, the teaching team found it tedious and time-consuming to manually review all the submitted forms, as an automated peer rating system was not used. The course leader met with a few students who made minimal or unequal contributions to the paired assignment and explained how and why their grades were reduced based on the overall rating in the peer assessment form. Their individual grades were calculated as described previously in the methodology section.

Guideline 3

Peer evaluation is a mechanism to identify students who do not contribute equally to the paired assessment. While some students may cover for their non-participatory partners, they are unlikely to rate highly if the partner consistently fails to contribute to the paired tasks. Students must be able to justify their rating. An automated peer rating system is highly recommended as it saves time when assessing student contributions. Peer reviews can be set up in most learning management systems, such as Canvas. Automated systems may help teachers easily identify non-participant students or students with low overall ratings so they can contact such students if necessary. Furthermore, teachers must conduct peer evaluations throughout the term or semester (for example, at the end of each milestone or phase in a project assessment) rather than at the end of the semester. Such ongoing evaluations will help identify non-participant students so that teachers can take appropriate measures (e.g., review sessions with the student, pairing with other partners) during the early phases of the project. A strict policy is recommended, where a student's grade is determined by their contribution, and part of the student's grades are contingent on completing peer evaluations to ensure students complete their evaluations (Williams et al., 2008).

STUDENT ATTENDANCE POLICY

The importance of regular attendance for the lab sessions was made clear to the students in the first week of the semester. However, as attendance was not mandatory for the labs and as students' absences did not have any penalty on their grades, absence issues were encountered with a few pairs where one of the student partners was either absent or late to the labs. The course leader and the teaching assistants dealt with each case separately in their lab sessions.

Guideline 4

Students are not only responsible for their own learning but are also accountable for their partner's learning and the overall pair performance. A strict attendance and student engagement policy is recommended to identify non-participating students in pairs. Teachers must monitor student engagement and attendance through learning management systems such as Canvas and analyse their weekly submissions of lab and assignment tasks. Such regular monitoring policies will help identify non-participating students so that teachers can take appropriate measures, such as reassigning students to different pairs earlier in the semester.

CONCLUSION

Collaborative learning approaches such as paired assessments can improve student understanding of the complex and ill-structured nature of modelling problems in database education. This study examined the impact of embedding IBL via a paired assessment in a large undergraduate Database System Design course. The aim was to understand (i) the effectiveness of a paired assessment approach in improving learning in a large introductory database course and (ii) student perceptions about working in pairs. Based on the data analysed, it is evident that embedding IBL via a pair assessment is

effective in teaching and learning fundamental database concepts. The study makes several contributions to the computing education literature. First, the overview of research on database education, collaborative and pair-learning, and IBL, along with the research findings, shows how embedding IBL via paired learning can address the collaborative needs of database education. Another important contribution is examining student perceptions of paired learning and peer evaluation by identifying key concepts/themes. Second, the description of a phased approach embedding IBL via a paired assessment can be adopted by database educators in their courses. Finally, this research presents four lessons learned and guidelines that will benefit database educators in computing, IS, IT, and software engineering curricula. To summarise, the study advocates (1) allowing students the choice to work with a partner or individually, as well as assigning pairs earlier in the semester, will help monitor their learning activities and provide timely, effective feedback; (2) implementing effective feedback strategies enhances students' understanding of feedback by clarifying roles and issues, correcting misunderstandings, and ensuring support for the students in their efforts and contribution to the paired assessment; (3) using a peer evaluation and rating mechanism to assess individual student's contribution and performance; and (4) enforcing a strict attendance and engagement policy for students.

The study has several limitations. First, the understanding of paired assessment in database education is based on a single large class within a specific university's degree program; therefore, these findings may not apply to other contexts. Future studies should investigate the effectiveness of paired assessment across institutions with similar undergraduate computing degree programs.

Additionally, this study did not consider the impact of factors such as students' background, experience (e.g., modelling, SQL), attendance, and task complexity on student performance. Other logistical factors, such as class size, may also significantly influence the approach. For example, small classes of around 40-50 students may have different logistical and pedagogical requirements compared to larger classes of over 300 students, like the one examined in this study. In this study's large class, it was essential to supplement the paired assessment with structured weekly formative lab tasks that aligned with the paired summative assessment phases. This included weekly practice quizzes, sessions for regular discussion and feedback, and the use of relevant tools and technologies (e.g., Visual Paradigm for UML, SQL Oracle Developer). Future research can replicate this study and conduct a deeper statistical analysis to control for potential confounding factors like prior knowledge, experience, and attendance, which may influence performance. Additionally, comparing these findings against other course occurrences over a longer period of time will help validate the results further. By understanding what makes paired assessment effective and identifying factors that contribute to its efficiency, we can create favourable teaching and learning conditions and avoid detrimental situations. This will help us determine when to implement paired assessments and when it may not be appropriate to do so.

REFERENCES

ACM Data Science Task Force. (2021). *Computing competencies for undergraduate data science curricula.* Association for Computing Machinery. https://doi.org/10.1145/3453538

Beck, K. (2000). *Extreme programming explained: Embrace change*. Addison-Wesley.

Bock, D. B., & Yager, S. E. (2005). Using the data modeling worksheet to improve novice data modeler performance. *Journal of Information Systems Education*, *16*(3), 341-350. https://jise.org/Volume16/n3/JISEv16n3p341.pdf

Bogdanova, D., & Snoeck, M. (2018). Learning from errors: Error-based exercises in domain modelling pedagogy. In R. Buchmann, D. Karagiannis, & M. Kirikova (Eds.), *The practice of enterprise modeling* (pp. 321-334). Springer. https://doi.org/10.1007/978-3-030-02302-7_20

Bogdanova, D., & Snoeck, M. (2019). CaMeLOT: An educational framework for conceptual data modelling. *Information and Software Technology*, *110*, 92-107. https://doi.org/10.1016/j.infsof.2019.02.006

Brown, S., & Klein, B. (2003). Small steps using cooperative learning techniques in the database management course: Some preliminary results. *Proceedings of the Americas Conference on Information Systems,* 3032-3038. http://aisel.aisnet.org/cgi/viewcontent.cgi?article=1862&context=amcis2003

Catania, B., Guerrini, G., & Traversaro, D. (2022). Collaborative learning in an introductory database course: A study with think-pair-share and team peer review. *Proceedings of the 1st International Workshop on Data Systems Education* (pp. 60-66). Association for Computing Machinery. https://doi.org/10.1145/3531072.3535330

CC2020 Task Force. (2020). *Computing curricula 2020: Paradigms for global computing education.* Association for Computing Machinery. https://doi.org/10.1145/3467967

Cliburn, D. C. (2003). Experiences with pair programming at a small college. *Journal of Computing Sciences in Colleges, 19*(1), 20-29. https://dl.acm.org/doi/abs/10.5555/948737.948741

Coleman, S. A., & Nichols, E. (2011). Embedding inquiry based learning into programming via paired assessment. *Innovation in Teaching and Learning in Information and Computer Sciences*, *10*(1), 72-77. https://doi.org/10.11120/ital.2011.10010072

Connolly, T. M., & Begg, C. E. (2006). A constructivist-based approach to teaching database analysis and design. *Journal of Information Systems Education*, *17*(1), 43-53. https://jise.org/volume17/n1/JISEv17n1p43.pdf

Demir, Ö., & Seferoglu, S. S. (2021). A comparison of solo and pair programming in terms of flow experience, coding quality, and coding achievement. *Journal of Educational Computing Research*, *58*(8), 1448-1466. https://doi.org/10.1177/0735633120949788

De Veaux, R. D., Agarwal, M., Averett, M., Baumer, B. S., Bray, A., Bressoud, T. C., Bryant, L., Cheng, L. Z., Francis, A., Gould, R., Kim, A. Y., Kretchmar, M., Lu, Q., Mosko, A., Nolan, D., Pelayo, R., Raleigh, S., Sethi, R. J., Sondjaja, M., … Ye, P. (2017). Curriculum guidelines for undergraduate programs in data science. *Annual Review of Statistics and its Application*, *4*, 15-30. https://doi.org/10.1146/annurev-statistics-060116-053930

Dybå, T., Arisholm, E., Sjoberg, D. I., Hannay, J. E., & Shull, F. (2007). Are two heads better than one? On the effectiveness of pair programming. *IEEE Software*, *24*(6), 12-15. https://doi.org/10.1109/MS.2007.158

Gehringer, E. F. (2003). A pair-programming experiment in a non-programming course. *Companion of the 18th Annual ACM SIGPLAN Conference on Object-oriented Programming, Systems, Languages, and Applications* (pp. 187-190). Association for Computing Machinery. https://doi.org/10.1145/949344.949397

Gordon, N., & Brayshaw, M. (2008). Inquiry based learning in computer science teaching in higher education. *Innovation in Teaching and Learning in Information and Computer Sciences*, *7*(1), 22-33. https://doi.org/10.11120/ital.2008.07010022

Graßl, I., & Fraser, G. (2024). Equitable student collaboration in pair programming. *Proceedings of the 46th International Conference on Software Engineering: Software Engineering Education and Training* (pp. 274-285). Association for Computing Machinery. https://doi.org/10.1145/3639474.3640086

Hawlitschek, A., Berndt, S., & Schulz, S. (2023). Empirical research on pair programming in higher education: A literature review. *Computer Science Education*, *33*(3), 400-428. https://doi.org/10.1080/08993408.2022.2039504

Huang, X.-p., & Leng, J. (2019). Design of database teaching model based on computational thinking training. *International Journal of Emerging Technologies in Learning*, *14*(8), 52-69. https://doi.org/10.3991/ijet.v14i08.10495

Katz, A. (2020). Improved teaching of database schema modeling by visualizing changes in levels of abstraction. *Journal of Information Systems Education*, *31*(4), 294-311. http://jise.org/Volume31/n4/JISEv31n4p294.html

Katz, A., & Shmallo, R. (2016). Learning from errors as a pedagogic approach for reaching a higher conceptual level in database modeling. In J. Krogstie, H. Mouratidis, & J. Su (Eds.), *Advanced information systems engineering workshops* (pp. 93-102). Springer. https://doi.org/10.1007/978-3-319-39564-7_9

Kaufman, D. B., Felder, R. M., & Fuller, H. (1999). Peer ratings in cooperative learning teams, *ASEE Annual Conference Proceedings*, (pp. 3931–3942). https://peer.asee.org/peer-ratings-in-cooperative-learning-teams

Leidig, P., & Salmela, H. (2021). *IS2020 A competency model for undergraduate programs in information systems*. https://www.acm.org/binaries/content/assets/education/curricula-recommendations/is2020.pdf

Love, B., Hodge, A., Corritore, C., & Ernst, D. C. (2015). Inquiry-based learning and the flipped classroom model. *PRIMUS*, *25*(8), 745-762. https://doi.org/10.1080/10511970.2015.1046005

McDowell, C., Hanks, B., & Werner, L. (2003). Experimenting with pair programming in the classroom. *Proceedings of the 8th Annual Conference on Innovation and Technology in Computer Science Education* (pp. 60-64). Association for Computing Machinery. https://doi.org/10.1145/961511.961531

Mitchell, A., & Vaughan, A. G. (2022). Implementing team-based learning: Findings from a database class. *Journal of Information Technology Education: Innovations in Practice*, *21*, 1-23. https://doi.org/10.28945/4903

Mitrovic, A., & Suraweera, P. (2016). Teaching database design with constraint-based tutors. *International Journal of Artificial Intelligence in Education*, *26*, 448-456. https://doi.org/10.1007/s40593-015-0084-6

Nicol, D. J., & Macfarlane-Dick, D. (2006). Formative assessment and self-regulated learning: A model and seven principles of good feedback practice. *Studies in Higher Education*, *31*(2), 199-218. https://doi.org/10.1080/03075070600572090

Orsmond, P., Merry, S., & Reiling, K. (2002). The use of exemplars and formative feedback when using student derived marking criteria in peer and self-assessment. *Assessment & Evaluation in Higher Education*, *27*(4), 309-323. https://doi.org/10.1080/0260293022000001337

Prince, M., & Felder, R. (2007). The many faces of inductive teaching and learning. *Journal of College Science Teaching*, *36*(5), 14-20.

Ramakrishna, M. V. (2000). A learning by doing model for teaching advanced databases. *Proceedings of the Australasian Conference on Computing Education* (pp. 203-207). Association for Computing Machinery. https://doi.org/10.1145/359369.359400

Salge, C. A. D. L., & Berente, N. (2016, January). Pair programming vs. solo programming: What do we know after 15 years of research? *Proceedings of the 49th Hawaii International Conference on System Sciences, Koloa, HI, USA,* 5398-5406. https://doi.org/10.1109/HICSS.2016.667

Salleh, N., Mendes, E., & Grundy, J. (2014). Investigating the effects of personality traits on pair programming in a higher education setting through a family of experiments. *Empirical Software Engineering*, *19*(3), 714-752. https://doi.org/10.1007/s10664-012-9238-4

Senapathi, M. (2004). Restructuring an undergraduate database management course for business students. *Issues in Informing Science & Information Technology*, *4,* 573-583. https://doi.org/10.28945/2787

Taipalus, T., & Seppänen, V. (2020). SQL education: A systematic mapping study and future research agenda. *ACM Transactions on Computing Education*, *20*(3), Article 20. https://doi.org/10.1145/3398377

Thomas, L., Ratcliffe, M., & Robertson, A. (2003). Code warriors and code-a-phobes: A study in attitude and pair programming. *ACM SIGCSE Bulletin*, *35*(1), 363-367. https://doi.org/10.1145/792548.612007

Topi, H., Valacich, J. S., Wright, R. T., Kaiser, K., Nunamaker, J. F., Jr., Sipior, J. C., & de Vreede, G. J. (2010). Curriculum guidelines for undergraduate degree programs in Information Systems. *Communications of the Association for Information Systems*, *26*, Article 18. https://doi.org/10.17705/1cais.02618

Umapathy, K., & Ritzhaupt, A. D. (2017). A meta-analysis of pair-programming in computer programming courses: Implications for educational practice. *ACM Transactions on Computing Education*, *17*(4), Article 16. https://doi.org/10.1145/2996201

Van Der Vyver, G., & Lane, M. (2003). Using a team-based approach in an IS course: An empirical study. *Journal of Information Technology Education: Research*, *2*, 393-406. https://doi.org/10.28945/337

Vygotsky, L. (1978). Interaction between learning and development. In M. Gauvain, & M. Cole (Eds.), *Mind and society* (2nd ed.). Harvard University Press.

Wagner, P. (2005). Teaching data modeling: Process and patterns. *Proceedings of the 10th Annual SIGCSE Conference on Innovation and Technology in Computer Science Education* (pp. 168-172). Association for Computing Machinery. https://doi.org/10.1145/1067445.1067493

Wang, N., & Ma, C. (2017, August). Teaching reform on database course for science laboratory class. *Proceedings of the 12th International Conference on Computer Science and Education, Houston, TX, USA,* 310-313. https://doi.org/10.1109/ICCSE.2017.8085508

Watson, R. T. (2006). The essential skills of data modeling. *Journal of Information Systems Education*, *17*(1), 39-42. http://jise.org/Volume17/n1/JISEv17n1p39.pdf

Williams, L., McCrickard, D. S., Layman, L., & Hussein, K. (2008, August). Eleven guidelines for implementing pair programming in the classroom. *Proceedings of the Agile 2008 Conference*, *Toronto, ON, Canada,* 445-452. https://doi.org/10.1109/Agile.2008.12

Williams, L. A., & Kessler, R. R. (2000). All I really need to know about pair programming I learned in kindergarten. *Communications of the ACM*, *43*(5), 108-114. https://doi.org/10.1145/332833.332848

AUTHOR

Dr. Mali Senapathi is a Senior Lecturer in the Computer and Information Sciences Department at the Auckland University of Technology, New Zealand. Her research interests include agile software development, digital transformation, and computing education. She holds a PhD in Information Systems from the University of Auckland, New Zealand. She has published in journals such as the *Journal of Systems and Software*, *Journal of Information Technology Education: Research*, *Journal of Software: Evolution and Process*, and *ACM Inroads*.