THE EFFECTS OF PROBLEM-BASED LEARNING VERSUS STRUCTURED TUTORIALS ON STUDENT ACHIEVEMENT IN A RELATIONAL DATABASE DESIGN ACTIVITY DURING ONLINE CONCEPT LEARNING

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The purpose of this study was to compare the effectiveness of two modes of instruction when teaching a complex topic in an online course. Additional variables included instructor monitoring and attitude towards group learning. Students in online courses that included Microsoft Access were the participants of the study. Participants were given either a problem based learning activity or a structured online tutorial to learn how to create an effective relational database.

Using the difference between pre- and post-test scores, there were no significant results. However, there were several interesting trends. Participants who engaged in the problem based learning activity performed better on the posttest than those who were given the structured online tutorial. One hypothesis was that students who preferred working in groups would perform better when given the problem based learning activity, and those who preferred working alone would perform better with the tutorial; results showed that those who preferred working alone performed better regardless of activity, and students who preferred to work in groups scored much lower on the posttest when assigned the tutorial, indicating that attitude towards group learning was more important for those who preferred working in groups.

Understanding how students learn and implementing the best ways to teach complex topics will result in greater comprehension and performance. More research is needed to determine best strategies, but this study introduced many combinations of teaching styles, attitudes towards group learning, and instructor communications, which all impact student achievement.

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CHAPTER 1

INTRODUCTION

As the number of web-based courses continues to increase, more attention is needed to determine how concepts are taught and learned online. Teaching abstract concepts such as relational database design can be especially problematic. Providing examples and hands-on activities, having students work in groups on practical problems, using social media tools like discussion boards, and providing video lectures are some ways in which the concepts can be presented. Additionally, the type of feedback provided may impact student participation, which, in turn, may affect how well students understand the concepts. The purpose of this study is to compare the effects of problem-based learning, structured tutorials, learning style preferences, and instructor monitoring methods on concept learning.

The number of college courses taught through distance learning (DL) has risen dramatically over the past ten years. According to the Sloan Consortium (Allen, 2013), the number of students taking at least one web-based course per semester increased from 9.7% in 2005 to 32% in 2011 (Allen, 2013). Assuming instructors provide quality instruction, students learn as much, if not more, content in a DL class than a live class. According to Lam (2009), 77% of academic leaders believe that learning outcomes in web-based classes are equal to or higher than those in face-to-face classes.

The delivery of instruction in DL classes has evolved in recent years from correspondence-type courses to classes on television to interactive web-based experiences. In web-based courses, interactivity includes student-to-student and student-to-instructor communications, as well as interactive instructional materials such as tutorials, virtual labs, and virtual tours. Most recently, emphasis in DL design has focused on helping students feel as if they are part of a live course. Most often, this interactivity has been provided through structured communications and group work. Unfortunately, not all students learn best in group environments and some students prefer to work independently (Pask, 1979).

Courses that consist primarily of reading and writing can be taught in a web-based environment where students discuss material asynchronously through discussion boards and synchronously through online chats. Courses that include skills such as computer programming or computer applications need to provide additional materials for students, since the instructors cannot demonstrate course tasks face-to-face. These courses often include step-by-step instructions, examples, and tutorials, as well as audio and video instruction.

Many have argued that a critical determinant of success in a web-based course is student interactivity. Student interactivity includes any type of communication or activity and has been shown to increase student satisfaction with a course. Increased satisfaction encourages students to complete and succeed in the course (Kim & Moore, 2005).

Structured Online Tutorials

One interactive method used to teach concepts is the structured tutorial. A structured online tutorial is defined as a web-based program that provides students with direct instruction via tutorials or practice problems (Kirkpatrick & Cuban, 1998). Students can complete web-based lessons at their own pace while selecting specific lessons to learn. The programs provide immediate feedback so students can monitor their level of understanding and competency.

In this study, a structured online tutorial consisted of a web-based lesson on relational databases created using *Adobe Flash*. The tutorial included instruction, practice problems, and feedback. It was self-paced, self-directed, and could be viewed multiple times. The lesson contained definitions of terms and objects, explanations of data types, examples of relational databases, and quizzes to test the users' knowledge. Appendix C contains screen shots and details regarding the lesson content.

Handy (2005) conducted a study in which students used a computerized tutorial to learn accounting concepts. Students found the tutorial helpful, since they were able to learn at their own pace, test themselves, and get immediate feedback. One advantage of structured tutorials is that students can skip modules that they already understand and spend additional time on new or difficult material. In typical structured tutorials, students interact with activities, quizzes, problems and other learning materials. Feedback is provided to help students to see how well they grasp the concepts and skills being taught. Students can then review and repeat difficult learning segments.

Problem-Based Learning

Problem-based learning (PBL) is an instructional approach designed to foster group problem-solving skills. In PBL, students work collaboratively in groups and are given a "real-world" problem to solve. The instructor acts as facilitator, providing resources and coaching to students, with limited direct instruction. Students gather information, formulate hypotheses, and generate solutions. Ultimately, students determine what skills are needed and identify resources to learn these skills, then work together to find solutions (Barell, 2007). Resources can include websites, tutorials, textbooks, reference books, and expert advice.

According to Barrows (1996), problem-based learning (PBL) has six core characteristics: 1) learning must be student-centered; 2) students are divided into small collaborative groups; 3) the instructor is expected to operate as a facilitator or guide, allowing students to discover the solutions instead of being told the answers; 4) students solve authentic, real-life problems; 5) real-life problems are used as tools to facilitate the acquisition of knowledge and problem-solving skills; and 6) knowledge and skills are acquired through self-directed learning. To determine how well students have learned content and skills, assessment allows students to apply problem-solving skills in related situations.

Reeves and Laffey (1999) studied PBL in an introductory engineering course at the U.S. Air Force Academy. One group of college freshmen worked in teams to solve problems about a "Mission to Mars." The other group received traditional lecture-style instruction. Students in the PBL group performed significantly better on achievement tests than students in the traditional class.

In this study, problem-based learning (PBL) activities included ill-defined problems given to small groups (4-5 participants). Students were expected to use any resources they would like while working together within their groups in an online discussion board to solve the problem presented. Resources could include the textbook, online tutorials and videos, other students, and examples provided by the instructor or textbook publishing company.

An example of a PBL activity in this study is as follows: "Fred owns 'The Reading Nook Bookstore.' He wants to keep track of customers, inventory, and sales. He would like to be able to send mailings and email blasts to customers. He also wants to create several reports: purchase details, books sold, number of customers, inventory lists with quantities on hand that are less than 5." See Appendix A for all of the scenarios used in the study.

Interactivity in Distance Learning Classes

The main techniques used to promote interactivity in distance learning are discussion boards, chat rooms, and email. Effective strategies for interactive instruction differ for different modes of instruction. In online PBL activities, students are usually given opportunities to interact in online asynchronous discussions. These discussions provide students with opportunities to think about each other's responses while contributing their own ideas (Ronteltap and Eurelings, 2002). In typical online PBL, students enter the online classroom at least once a day to engage in discussion forums. In addition, they may decide to meet in chat rooms to actively collaborate, just as students in conventional classes might meet in person to work together. In addition to synchronous online meetings in chat rooms, asynchronous discussions or email can also be used as vehicles for collaboration in online PBL activities.

A discussion board is a website that allows students to post comments or questions. In an online classroom, discussion boards are generally restricted to students enrolled in a particular course. The instructor usually enters a question or describes a situation. Students post replies asynchronously. Discussions can be established for entire classes and/or for small groups within the class. In most instructional discussion boards, students can also initiate topics along with instructor topics. In this study, the discussion board was developed in *Blackboard Learn* and available for students in PBL groups to communicate with each other. A PBL scenario (see Appendix A) was given to each group of students. Students used the discussion board to post ideas and information as they worked together to create a relational database based on the scenario.

Instructor Monitoring Method

Interactivity in web-based classes includes communication between students as well as communication between students and the instructor. Instructor feedback and quantity of discussion posts may have an effect on the quality of students' responses in discussions. An, Shin, and Lin (2009) determined that instructors' discussion posts that gave encouragement or constructive feedback resulted in increased discussion activity. However, too much instructor interaction reduced peer-to-peer communication.

Denner (2005) found similar results. When instructor feedback was timely and substantive, there was a higher level of student dialogue. Conversely, when the instructor responded too quickly after a student post, student responses decreased. On the other hand, if there was no instructor presence in the discussions, there were fewer student posts. In addition to communication from the instructor in the discussions, the researchers suggested that structured assessments should be used to evaluate student posts and encourage more interaction from the students.

In this study, instructor monitoring was either active or passive. With the active monitoring, the instructor sent email to each student that included constructive criticism and encouragement. Passive monitoring consisted of no email. The instructor simply watched student activity. Additional instructor-student communications were found in the discussions for problem based learning activities.

Relational Database Concepts

A database is used to track data. Data is stored in tables. To increase efficiency and reduce redundancy, tables are designed to relate to each other using key fields to connect information. The design of a relational database allows users to sort and filter to extract information easily (Kroenke, 2006).

A relational database consists of tables, fields, key fields, and relationships between key fields to link tables together. Based on the RDMS model (Darwen, 2012), the tables are expected to be constructed in a way that eliminates (or reduces) redundancy of information.

The planning and creation of an effective relational database requires time, logic, and practice. An effective relational database contains tables of information that relate to each other by connecting common categories of information. For example, a relational database could be used to manage aspects of a retail environment such as customers, inventory, and sales. Designing this database would require analyzing types of data and reports that would be required to manage the store. These reports might include lists of customers; lists and quantities of inventory; and sales totals by month, product, or customer.

In database design, identifying the data tracking and reporting needs determines the structure of the database. After a rough model is drafted, it is analyzed to ensure that the data model is efficient and complete. Once the data structure is defined, it can then be populated, tested, and refined until it meets the needs of the user (Kroenke, 2006). Along with a conceptual understanding of database design, students need the ability to create usable databases, tables, queries, and reports in a software application such as *Microsoft Access*.

In a traditional classroom, the instructor can work directly with students to teach database design through live discussion and demonstrations. In web-based courses, methods of instruction generally include asynchronous discussion boards, live chats, video lectures, and demonstrations.

In this study, designing a relational database is an example of a complex conceptual learning task because it requires more than a simple answer, since there is not one definitive approach. It was the main focus of lessons, activities, and assessment.

Attitude Towards Group Learning

Attitude towards group learning refers to whether students prefer working in groups or working alone. This is one aspect of Memletics Learning System, which consists of 70 statements that are grouped into seven categories: visual, aural, verbal, physical, logical, social, and solitary (Memletics High Performance Learning, 2015).

Much research has been done examining the relationship between learning style preferences and method of instruction. Mokmin and Masood (2015) divided their math class in half in which one group matched learning styles to activities and the other group was not matched. Results showed that students whose learning styles were matched to the activities performed better on the posttest than those who were not.

There have been conflicting studies showing that learning style preferences have no impact on method of instruction. For example, Davis and Franklin (2004) found no correlation between performance and preference. Students adapted to whichever method of instruction was presented.

In this study, attitude towards group learning was measured through a 10-question adapted version of Memletics Learning Styles Inventory. This score was used to evaluate whether a relationship existed between attitude towards group learning and method of instruction.

Statement of Problem and Research Questions

Several variables can impact student success in web-based courses. When the courses contain complex, abstract concepts, different methods can be used to teach these concepts. While instructor-student interaction is a factor in student success and course satisfaction, different types of interaction may be more effective with different content and activities. This study compared method of teaching, attitude towards group learning, and instructor monitoring method on learning database design concepts.

Specific research questions include:

1) Is there a difference in achievement between students who engaged in web-based problem-based learning versus structured online tutorials?
2) Is there a difference in achievement between students who receive active instructor monitoring versus those who received passive instructor monitoring?
3) Is there a difference in achievement between students who prefer working in groups and students who prefer to work alone?
4) Is there an interaction between instructor monitoring method (active vs passive) and method of instruction (PBL vs structured online tutorials) in a web-based class?
5) Is there an interaction between attitude towards group learning and method of instruction?
6) Is there an interaction between instructor monitoring method and attitude towards group learning?

7) Is there an interaction between attitude towards group learning, method of instruction, and instructor monitoring method in a web-based class?

Significance of the Study

Students can obtain entire degrees without taking a live, traditional class. To be prepared for the workforce, students must be able to work in groups, solve problems, and apply skills in various situations. While it has been shown that there is no difference in comprehension of content between DL and live courses (Lam, 2009), more research is needed to evaluate the effects of online instruction on comprehension and application of abstract concepts. It is important to determine effective methods to teach concepts and the application of conceptual knowledge and how these may be impacted by students' preference of learning style. Likewise, it is important to determine optimal approaches for providing students with feedback when students have varying amounts of prior knowledge.

Summary

While studies have been conducted to evaluate the effectiveness of PBL and structured online tutorials, and studies have shown that increased communication with instructors correlates with students' attitudes toward their courses, there are few studies that have looked at the interaction between instructional strategy and instructor monitoring method. Additionally, little research has been conducted on the interaction between student attitudes towards group work and instructional strategy (PBL or structured online tutorials).

Results of this study can be used to help instructors who teach concepts in online courses understand which modes of instruction are most effective with different groups of students. Using instructor monitoring appropriately will encourage student participation, thereby enhancing students' learning and level of course satisfaction. In addition, applying these findings will improve the quality of instruction in web-based courses.

CHAPTER 2

REVIEW OF THE LITERATURE

Introduction

The purpose of this study is to compare two teaching methods of a complex problem, relational database design, in a web-based class by varying the method of instruction (problem-based learning versus structured online tutorial), type of instructor monitoring (active versus passive), and attitude towards group learning (group versus alone). Prior experience was also taken into consideration and was used as a covariate. This chapter provides a review of the relevant literature and details recent research on methods of teaching complex topics, problem based learning, structured tutorials, attitude towards group learnings, and instructor monitoring methods.

Problem Solving

Relational database design is an example of a real-world, complex problem. Stice (1987) reviewed definitions and strategies for problem solving before explaining how to teach the process. He determined that problem solving refers to perceptual and conceptual tasks that are understood but cannot be completed. To solve the problem, Stice recommended a 5-step process: 1) define the problem, 2) think about it (identify attributes and area of knowledge, then collect information), 3) plan strategy, 4) carry out plan and solve the problem, and 5) evaluate.

To solve complex problems, prerequisite skills and underlying knowledge should be learned first. There should be examples and practice to help prepare for undertaking the actual problem. Practice may include tips on general problem solving and some strategies for defining ill-defined problems (Ormrod, 1990). This approach maximizes working memory capacity without overloading it, thereby allowing students to save, then retrieve, strategies from long-term memory.

Gagné (1980) noted there are three types of capabilities that an individual needs for problem solving: intellectual skills, verbal knowledge, and cognitive strategies. One may have intellectual skills and knowledge but may need to develop strategies to solve problems that use that knowledge. Students can be taught problem solving strategies to apply to specific situations, but they need a combination of intellectual skills and the ability to verbalize in order to apply problem solving techniques. Selecting among different strategies to solve problems seems to be a direct result of prior problem solving experience and reflective thought.

Previous research has identified four elements that are helpful in learning to apply problem solving strategies in real-world problem solving: 1) contextual learning through PBL activities, 2) peer-based learning where peers work together to achieve a goal, 3) activity-based practice in which students learn by doing, and 4) reflective practice where students reflect on their experience (Johnson, 1997).

In this study, relational database design was the complex problem that was taught. The following studies illustrate different approaches to teach problem solving, then focus on the specifics of relational databases. Some of these approaches include using computer simulations, incorporating collaborative learning, and providing guidance and support. Reducing cognitive load is an important factor when determining effectiveness of the teach approaches implemented.

Computer simulations may be helpful in supporting instruction for problem solving strategies. A computer-based business simulation called "Jeans Factory" was used to teach fundamental economic concepts to high school students. Students worked together to determine how many and which goods to produce in order to gain the most profit. Once decisions were made, the simulation was run. Students were provided with graphics and tables to show how well their company performed compared to its competitors. Based on these results, students altered conditions, quantities, and selected goods, then ran the simulation again. Running the simulation multiple times gave students an opportunity to evaluate the effectiveness of their decisions. Half of the students were given guidance to help them with problem solving activities, while the other half were not. Those receiving guidance were given specific problem solving steps to follow: 1) gather information and analyze data, 2) define and justify decisions, 3) predict competitors' and own prices and profits, and 4) evaluate results, compare predictions, and draw conclusions. Students with problem solving guidance performed significantly better than those without (Stark, Gruber, Renkl, & Mandl, 1998). This study illustrated the effectiveness of providing instructor guidance for students engaged in a computer simulation activity.

Another approach was to incorporate collaborative learning to help students learn problem solving strategies. Collaborative learning included group learning in regularly scheduled sessions, student-created study groups, and online discussion groups. Love, Keinert, and Shelley (2006) redesigned a course teaching discrete math topics to address high failure rates, lack of ability to analyze problems, lack of basic algebra skills, and inability to relate math to other disciplines. To counter these issues, the new course was divided into modules, used collaborative learning methods, had a flexible learning environment with 24/7 access, provided support through regular class sessions and online tutoring, and incorporated learning through real applications. Results showed that students in the new course performed better than the control group. It was noted that keeping students engaged was necessary for success since it was determined that students who completed the tasks received A's and B's; whereas those who did not received failing grades. It was recommended that instructors should email students who were not performing well to encourage participation. In addition to collaborative learning and student participation, instructor support was also an important factor in student success.

However, while guidance and support have been used to help students with problem solving, the amount and type of support may have an impact. Slof, Erkens, Kirschner, Jaspers, and Janssen (2010) provided task support to guide student interactions in a high school economics course. Three types of flowcharts were used: conceptual, causal, and simulation. The conceptual flowchart was a basic chart with no annotations, the causal version had added details, and the simulation version included examples with costs within the boxes of the flowchart. Results showed that the causal flowchart was most effective since it added details without examples. It is possible that while the basic chart did not provide enough information, the simulation offered too much extraneous information that could not be effectively processed, resulting in cognitive overload.

Cognitive load was also a factor when Braithwaite and Goldstone (2015) explored the impact of variation and prior knowledge solving probability problems. For those without prior knowledge, students performed better when they were presented with similar examples. For those with prior knowledge, scores were higher when given varied examples. It was determined that students needed to learn the basics before they could apply and adapt for different types of examples. Instruction that initially presented similar examples provided students with a base of knowledge. This allowed students to internalize the information before facing more complicated examples, thereby keeping cognitive load at a manageable level.

Programming languages are also taught by starting with the basics and moving on to more complex situations. However, Machanick (2007) tested the idea of teaching Java backwards. He taught abstraction first by hiding details until students were ready. The approach was to explore what needed to be done before students learned how to do it. Students performed better than those given the traditional approach. This top-to-bottom approach helped students remember the goal while learning how to achieve it.

As illustrated in these studies, to effectively teach how to solve a complex problem, different combinations of techniques can be used. Teaching top-to-bottom (goal to tasks) and bottom-to-top (learning tasks then applying to goals) were both helpful. Reducing cognitive load enabled students to learn and use new skills more efficiently. Collaborative activities, including PBL, were also valuable. Using instructor guidance and real life situations with which students could relate helped students assimilate the information and skills presented. Simulations and structured tutorials have also proven to be useful.

Relational Database Concepts

While the previous section examined studies conducted on different types of problems in a variety of subject areas, this section focuses on a specific example of designing relational databases. When designing an effective relational database, the object is to create a database that has little to no redundancy in which no identical data is entered into multiple tables. Each table contains a specific portion of the data. Tables and their information are joined through key fields by queries used to build reports (Kroenke, 2011). As with other complex skills and problems, researchers have examined various methods to teach relational databases.

Critical concepts in relational databases include the Entity-Relationship (E-R) model. This model contains entities, attributes, identifiers, and relationships (Kroenke, 2011). *Entities* are objects users want to track. Examples of *entities* might include customers, products, and orders. *Entities* have *attributes* that describe the entity's characteristics; for example, *attributes* for customer might include firstName, lastName, and Address fields. *Identifiers* are usually primary keys whereby each record in a table (or entity) can be identified by a unique alphanumeric value. *Relationships* connect *entities* to each other. For example, tables are connected to each other through primary and foreign keys, *identifiers,* within each table that are unique and non-unique, respectively (Kroenke, 2011).

Philip (2007) found that the concept of database modeling and design was difficult for students to understand. He reviewed several approaches found in different textbooks. The top-down approach consisted of three steps: 1) create the conceptual schema represented by Entity-Relationship (E-R) models, 2) create a logical schema by mapping conceptual schema to relation schemas using mapping rules, and 3) apply normalization rules to test the quality of the design and improve the design if necessary. Common mistakes were made in identifying primary keys and relationships between tables. Other problems occurred when normalizing data. Difficulties arose because students did not understand how or why to reduce redundancy. It was suggested that providing examples that illustrate the issues helped students understand the concepts and solutions to the problems.

While some literature has focused on what information to teach, little research has focused on how to teach the database concepts to make them more concrete and understandable. Dominguez and Jaime (2010) gathered data on different approaches to teaching databases over a five-year period. For the first three years, only lecture-based instruction was given. During the last two years, students could elect to work on problem-based learning activities online. In the online alternative, students had access to discussions, email, and chats. All students had access to online resources. Results showed that students who worked in the PBL groups scored significantly higher on the exams than students who only received lecture-based lessons. While not directly measured, it was concluded that students in the PBL groups benefited from the experience because it helped them with reflective thinking skills, collaborating and communication capabilities, and development of work skills where students adhered to deadlines. Due to the nature of PBL activities, students were able to discuss the problem with others and work together to find solutions.

In another study, an online animated tutorial was created to teach the E-R Model concept and design. It included lessons on designing the database and several scenarios. It also explained how to normalize data (to reduce redundancy). In a pilot study, students who used the tutorial performed better on the examinations than students who did not use the tutorial (Murray & Guimaraes, 2009).

The research presented shows that both PBL and tutorials can be effective in teaching the complex problem of relational database design. Additionally, explanations and examples should be concrete and guidance may be needed to help students complete the tasks.

Online Problem-Based Learning

Problem-based learning (PBL) is one of the modes of instruction used in this study. It is a method of instruction in which students must take responsibility for their own learning because instructors act as facilitators instead of lecturers or direct leaders. Instructors present authentic, real-world, and well- or ill-structured problems to students who work independently and within groups to solve these problems. Students are self-directed and learn what is needed to help them design solutions for the problems (Barrows, 1996). Many researchers studying PBL have referred to Barrows (Barrows, 1996) to gather guidelines for implementing PBL (Gremler, Hoffman, Keaveney, & Wright, 2000, Hmelo-Silver, 2004).

Based on a meta-analysis of studies, Koschmann, Myers, Feltovich, and Barrows (1994) determined there were six principles of effective learning and instruction: multiple views and interpretations of information, active learning, ability to articulate newly gained knowledge, adaptation and accommodation of new information, authentic activities, and lifelong commitment to learning. The researchers concluded that successfully executed PBL activities included all of these principles through the use of student-centered collaborative learning and real-world problems.

The following studies illustrate how to incorporate PBL activities and the results of these experiences in a variety of classroom situations. These studies have been organized into several areas to show how the key components of PBL have impacted the success of the PBL activities: ill-defined problems, small groups and interaction, guidance, resources, motivation, concepts versus facts, and assessments.

Ill-defined and Authentic Problems

One of the key components of successful PBL activities is that the problems should be ill-defined and authentic. Ill-structured problems do not have a correct solution; as information is gathered, the problem and ideas around the problem may change. Authentic problems are real-life situations that are relevant to the learners (Sungur, Tekkaya, & Geban, 2006).

Reeves and Laffey (1999) presented one group of undergraduates ill-defined engineering problems for which goals and solutions were not clearly presented. The other group received lecture-style instruction and were given tasks that required students to solve problems based on examples. Results suggested that PBL significantly improved learning of engineering concepts and ability to solve problems, especially when ill-defined problems were used.

When creating PBL lessons, Herrington, Reeves, and Laffey (2006) focused on using authentic tasks, which consisted of activities that mirrored real-world tasks of professionals rather than classroom-based tasks. When the assignment was ill-structured, where few details were provided, students needed to define the task and determine sub-tasks to complete the activity. The researchers concluded that assignments need to be complex enough to span days or weeks and should use synergistic approaches that combine learner, task, and technology to promote collaborative learning and an examination of the task from different perspectives. When authentic tasks were assigned in which students determined paths to take to complete them, the tasks fostered ownership of learning, which resulted in greater satisfaction with the course. Course satisfaction resulted in higher motivation to solve the problems.

Given the difficulties students face when initially encountering PBL activities, Chin and Chia (2005) studied how the ill-structured authentic problems influenced the way students approached the problems, what issues and problems existed when implementing the project, and how teachers can guide student learning effectively. The researchers conducted a qualitative study in which students were given open-ended problems about food and nutrition. It was determined that students had different techniques for gathering information such as using library books and other printed materials, surfing the Internet, conducting surveys and field studies, and completing laboratory investigations. As facilitator, the teacher asked questions to help students focus on relevant information, added time constraints, and provided encouragement to deal with some of the issues that arose. When compared with previous lessons, in which students were given more structured problems and tasks, ill-structured problems motivated students to find resources so problems could be solved.

Based on the research, ill-structured authentic problems prompted students to search for information and solutions in a variety of ways. Using different resources such as Internet, textbook, library, and other students in the group, students gained better understanding of the situations and provided solutions that were more in-depth. Conversely, had students been given problems that were more defined, students may not have explored other avenues to derive answers.

Groups and Interactions

Along with ill-structured problems, another key component to PBL is group work. Dealing with members of a group can be challenging, especially when the group is online. It is difficult to find time to talk, whether synchronously or asynchronously, and move toward a solution. The following studies illustrate different approaches and their effectiveness in helping students work together to solve problems.

According to Gremler, Hoffman, Keaveney, and Wright (2000) and based on Barrow's research (Barrows, 1996, Barrows, 2002), when designing PBL activities, the following principles should guide the creation of a learner-centered environment: 1) incorporate student-faculty contact since students will be more motivated if they connect with their instructors; 2) encourage cooperation among students to stimulate communication within their groups; 3) promote active learning so students search for information they need to solve problems instead of waiting for answers to be given to them; 4) give prompt feedback that is constructive so students know if they are on the right track; 5) emphasize time on task to help students prioritize and improve their time management skills; 6) communicate high expectations; and 7) respect diverse talents and ways of learning to encourage students to approach the material in whatever way is best for each student.

Through a review of several studies, Lehtinen (2002) examined different approaches to converting face-to-face PBL to online instruction. Critical issues included ensuring enough student-student and student-instructor interactivity and if the types of problems actually fostered PBL. He concluded that more effective tools such as discussion forums and chat rooms needed to be developed for communication and research in order for online PBL to be successful.

Dunlap, Furtak, and Tucker (2009) compared the effectiveness of PBL in online versus live physics classes. They noted that the biggest issue was ensuring that online groups could interact as often as needed and on any day or time, whether it was through chats or discussion forums. While technical software problems limited the utility of the presentations that included simulated social interactions, students in the online course performed significantly better than those in the live class on an energy concept posttest. Researchers recommended that stable and ever-present online tools be used to ensure that students could communicate asynchronously and review material at their convenience.

The use of roles within PBL tasks was examined with graduate students learning to assist visually impaired students (McLinden, McCall, Hinton, & Weston, 2006).

Results from a survey showed that students liked having specific roles assigned to group members because it added structure. Roles of “chairperson” and “summarizer” rotated from person to person within each group. While some students indicated they would have preferred face-to-face meetings, most grew more comfortable with online group work as the course unfolded. Some students had difficulty managing their time in order to accomplish their tasks but continued with the activity to avoid disapproving coworkers. It appeared that sense of responsibility to the team and, possibly, the roles the students had within the groups inspired students to complete the activity.

Hmelo-Silver (2004) analyzed several studies and concluded that collaboration was a critical factor in a successful PBL activity. Good collaboration includes participation from all members and involves brainstorming, problem formulation, data collection, analysis, review, and evaluation. It was determined that in order to engage in PBL, students needed to learn how to collaborate and search for information. To teach students these skills, they began with a tutorial. The PBL tutorial presented a group of students with minimal information about a complex problem. Students needed to ask the instructor questions to gain further information and needed to gather facts by doing research. Students were encouraged to reflect on their self-directed learning and determine what they had to learn and how to get the information. They used a chart to break down facts, ideas, learning issues, and action plans. During the activity, the facilitator helped students through modeling and coaching through the use of questioning strategies. This scaffolding decreased as students improved their ability to determine and find what they needed to learn. Collaboration was key to the process. Assigning roles to students within the groups helped them collaborate. Acquiring problem-solving and self-directed learning skills was also essential. Through her analysis of others' research, the researcher determined that students who needed to develop self-directed learning skills had greater difficulty with PBL, and required more guidance through the process. Guidance included worksheets along with hints and feedback from the instructor. This study illustrated the importance of collaboration, instructor guidance, and self-directed ability to solve problems.

Since collaboration and communication are so important to the success of PBL activities, Ronteltap and Eurelings (2002) examined differences in communication when students were given practical ("knowing how") versus theoretical ("knowing what") problems. While students initiated posts about theoretical issues, there was much more communication and dialogue when practical issues were presented. Student posts were analyzed for level of cognitive activity and categorized as follows: learning issues, information from documents, and responses to others. Posts were also evaluated for their originality versus simply copying and pasting or rephrasing what had been uncovered in documents. Researchers determined that practical learning issues promoted more collaboration and a higher level of processing information in which students synthesized information learned and were able to apply what they had learned.

Orrill (2002) compared two PBL approaches in online graduate-level education classes. The first group's course spanned an entire semester in which students were given eleven weeks of collaborative work followed by three weeks of PBL. The second group's course was conducted in a shorter summer session and consisted of one week of collaborative work before starting the three weeks of PBL. Posts were categorized as problem solving, task, other, and combinations of these. Students were also expected to label their posts (ex.: response, summary, action, idea). Students in the second group had many more posts which dealt with solving the problem and dealing with the tasks needed to be done; whereas, the first group had fewer total posts and did not include any integration of problem solving and tasks. An analysis of discussion posts showed that the second group, that focused on problem solving (with fewer posts outside of the main task), was better able to summarize the learning.

These studies illustrated difficulties students had communicating effectively with others. Clear roles and instructions for working together in groups were needed. To communicate with each other, adequate time and tools such as discussion boards, chatrooms, and meeting spaces must be available. To ensure students were collaborating successfully in order to complete the tasks, guidance from the instructor such as providing guided questions, worksheets, and hints was found to be effective.

Guidance

As suggested, students need guidance from the instructor to ensure students are making progress. Guidance may include assignment directions and clarifications, constructive criticism posted in the discussion forums, and helpful hints. The following studies demonstrate under what conditions different types of guidance can be effective in PBL activities.

An and Reigeluth (2008) reviewed three courses that used PBL activities to create practical guidelines for designing and implementing PBL online. Based on data collected through interviews, observations, and document reviews, they created lists of strategies for faculty to implement. The strategy included a flexible structure in which students could interact synchronously and asynchronously. Posing questions about the topic and suggesting resources to use were examples of scaffolding that was needed to help guide students. Since students had difficulty knowing where or how to start, specific instructions were required to motivate students to begin the activities. Optimal group size was found to be 4-5 students. Students who had not previously participated in PBL activities benefitted from practice exercises before engaging in the main activity. Students also needed help within the groups to learn how to collaborate. It was determined that instructor guidance provided students with structure to enable students to successfully complete PBL activities.

Barrows and Tamblyn (1980) determined that difficulties with PBL were generally due to poor understanding of the process of completing the PBL activities by both students and teachers. Students may have been hesitant to start an activity when the problem was unknown and felt they did not have enough information about the topic. They may have wasted time focusing on aspects that were not important. Teachers needed to feel the activity was relevant and a good strategy or it would be considered pointless. For students, clear explanations of the PBL activity process and goals were needed along with scaffolding (i.e.: feedback, hints, steps to follow) by teachers to help students pay attention to relevant tasks and information. Also, Barrows and Tamblyn concluded that students needed to apply what they learned and review the process and results; otherwise, the activity would not have been effective.

Van Barneveld (2011) examined anxiety of engineering educators over success in class when implementing PBL in a traditionally-oriented college atmosphere. The researcher gathered information through an online survey. Results indicated that greatest tensions were students' initial discomfort with PBL, educators' roles as instructor versus facilitator, and individual versus organizational value assigned to teaching. Expectations were explained to alleviate student issues. Students had difficulties taking responsibility for their learning. Problems with instructor as a facilitator were remedied over time as instructors learned to offer suggestions instead of providing direct information and realized that they continued to be educators in role of facilitator. Instructors set the stage by explaining the process and expectations. They provided additional guidance throughout the activity by providing class time and feedback to help students gather information, use time efficiently, and work in groups. Since PBL was used in many courses, as students moved from beginning to capstone courses, students were better able to work in groups without added support, so structure and boundaries were lessened, creating a more open-ended environment for the higher level courses.

Based on a meta-analysis of previous studies, Hmelo-Silver, Duncan, and Chinn (2007) determined that PBL and inquiry learning require scaffolding. Examples of scaffolding included providing models and examples, using guided instruction through templates and worksheets, and helping students focus on relevant facts and tasks. Focusing on relevant issues reduced cognitive load, which allowed students to solve problems more easily. The amount of scaffolding differed based on students' experience level with PBL. Kirschner, Sweller, and Clark (2006) also found that when students were not provided with the right resources or guided learning tools, students acquired incorrect information or simply could not process what they had uncovered. Providing guided instruction through worksheets and examples helped students focus on relevant tasks and information, which reduced the possibility of an overload in working memory.

Walker, Recker, Robertshaw, Olsen, Leary, Ye, and Sellers (2011) conducted a two-part study to test the effectiveness of PBL on technology-oriented professional development to help teachers find online learning resources and use them to design effective PBL activities for students. The participants, who were given PBL activities, were divided into two groups in which the first group learned how to design PBL activities while learning the software application, whereas the second group learned how to use the technology then how to design PBL activities. Results indicated that those who learned how to use the software before engaging in PBL performed better. This suggests that if skills can be integrated with discussions, then learning skills concurrently could work. However, if skills are too intricate, it may be best to divide the activities whereby the PBL activities are used for their problem-solving capabilities after the technology skills have been learned. These techniques help to reduce cognitive load since the participants did not need to keep information in working memory for multiple skills or activities simultaneously (Ormrod, 2010).

Based on the research presented, it is necessary for instructors to provide guidance within PBL activities to help students search for relevant resources, complete tasks in the time allotted, and synthesize information. Guidance can include giving helpful hints; offering suggestions of resources; and providing constructive criticism, calendars, and worksheets. The amount of guidance presented is dependent upon the needs of the students. This guidance can help prevent cognitive overload, allowing students to process information more efficiently.

Resources

In PBL activities, students are expected to search for information to solve the problem provided. A list of resources may help students focus their research. Resources include textbooks, tutorials, and specific books and websites. Providing this list of resources is another form of guidance. While providing these tools may help students focus their attention and reduce time spent searching for information, determining type and quantity of resources to list is important. The following studies demonstrate attributes to consider when providing resources to students.

Medical students in Munich used *PlanAlyser* to research information needed to solve their PBL problems. Within the *PlanAlyser* system, there were hypertext links to other text-based or graphical information. When students were not told about the importance of the hyperlinks, they did not click on them or look up the information available. However, students in a second study were informed about the links and were provided with graphical information. Students who accessed this information performed better on post-tests on the subject (Grasel, Fischer, & Mandl, 2001). In this situation, students needed guidance to learn how to use the resources provided.

In a study conducted by Jeong and Hmelo-Silver (2010), student use of online resources was examined. The resources were pre-selected videos and online documents. Results showed that students in the higher-achieving group visited the resources more often. It was concluded that students needed to understand how to access and use the resources then learn to process and share the information gathered to help them solve problems.

Roy and McMahon (2012) tested the difference between providing audio/video and written transcripts in problem-based learning cases. Based on a survey given, students preferred video, but higher rates of deeper thinking were exhibited within the text-only group. This indicated that preference over audio or video had no impact on the results. However, providing video may have given students a base of information that helped them understand other text-based resources. Regardless of whether the students received text or video resources, the PBL activities were successfully completed.

These studies showed that providing a list of resources may help students focus their attention. Resources that include a variety of media allow students to select the mode in which they prefer to learn information. Students may need instruction on how to use resources effectively (Jeong & Hmelo-Silver, 2010; Grasel, Fischer, & Mandl, 2001).

Motivation

Since PBL activities do require more time than other instructional methods, students may need to be motivated to put in the time needed. However, when students are engaged in PBL activities, they often have reported enjoying the course more, spending more time working on assignments, and ultimately, doing better in the course. With PBL activities, active learning allows students to control their learning, which is especially important with adult learners (Knowles, 2015).

Rounds and Rappaport (2008) used PBL in an online class with nursing students. They noted that PBL supported adult and student-centered learning while also promoting the characteristics needed to be a successful online student. These characteristics included independence, self-discipline, the ability to adapt to new learning environments, high levels of motivation, and good organizational skills. Researchers observed that during the study, students became more independent, learned to share responsibilities, and acquired skills and concepts needed to complete the activities. An advantage was that not only did the PBL activities help students learn, they also improved students' performance in other online classes.

Williams (2008) examined PBL in different countries. In Australia, students completed a PBL project on solar energy. The structure of the PBL process included: 1) the case problem was presented; 2) students engaged in group discussions in which they identified the problems, generated hypotheses, gathered additional data, and determined issues and tasks; 3) students then had time for independent tasks; and 4) once completed, they met with their groups to discuss, synthesize, and review. Results showed that students had higher levels of satisfaction in group work and enjoyed the learner-centered approach over direct instruction.

Based on these studies, PBL activities inspired students to work to complete the tasks, which students seemed to enjoy. Since PBL activities allow students to structure their own learning, the activities were more motivating for students. An additional benefit was that the activities helped teach students better time-management skills and self-discipline, which enhanced students' ability to complete the activities. Even though

PBL activities required more time than other activities (i.e. tutorials, readings, lecture), the nature of the activities (ill-structured problems, student-centered learning, collaboration) motivated students to attend to the tasks required to successfully achieve the goals of the activities.

Problem-Solving Versus Learning "Facts"

As described previously, effective PBL activities consist of ill-structured authentic problems that need to be solved. While students learn information when they are working towards a solution, the following research indicates that engaging in PBL activities may not be the best approach for learning facts.

In a meta-analysis of studies using PBL to prepare teachers, Bridges & Hallinger (1997) found that students expressed higher satisfaction, felt better prepared to enter the working world, rated the learning environment better in PBL than the direct instruction environment, studied for understanding instead of just learning the facts, and gained greater clinical knowledge. However, students receiving traditional instruction scored higher on science exams than those engaged in PBL activities. The authors concluded that PBL activities were more appropriate for problem solving tasks than for memorizing facts.

Sendag and Odabasi (2009) investigated online PBL's effect on critical thinking skills and content acquisition. Critical thinking skills involved defining the problem, determining possible solutions and assumptions, drawing conclusions, and evaluating those conclusions. A pretest-posttest design was used in which students were divided into two groups: one received PBL activities, and the other learned information from the instructor. Those who completed the PBL activities performed significantly better on the critical thinking skills test than those in the control group. The same was true for content acquisition, but the difference was not significant. This supported other studies' results in which it was determined that PBL was better used to learn concepts and problem solving skills and not as effective for learning facts.

Similarly, Gijbels, Dochy, van den Bossche, and Sergers (2005) performed a meta-analysis to determine the effects of PBL when assessment focused on understanding the concepts, understanding principles that link concepts, and linking concepts and principles to conditions and procedures for application. The researchers selected empirical studies that fit Barrow's model (Barrows, 2002). The main effects for learning principles and application were significant, but learning concepts was not, indicating that PBL activities were more effective for learning broader principles that could be transferred and used in other activities.

Ozan et al. (2005) examined the use of PBL as the main instruction in a medical school program. Students evaluated the program's effectiveness on different skills including basic knowledge, emergency intervention, problem-solving skills, and conducting physical examinations. Results indicated that students learned the least on basic facts and more on skills that required problem solving.

This body of research showed that PBL activities were best used for problem solving and not as effective when facts needed to be learned. PBL activities allowed students to apply the concepts learned to new situations. Other methods of instruction may be more effective for teaching facts.

Assessment

Since PBL activities are best used with problem solving and concept acquisition, and schools need to test students on their knowledge, it is important to examine how students are evaluated when given PBL activities. Multiple choice and true/false questions work well for assessing basic knowledge; however, skills and concepts learned through PBL activities may need to be evaluated through other types of questions or activities.

Li-Ling and Suh-Ing (2006) used online discussions with groups of nursing students to work on ill-structured cases. Students determined expected learning outcomes, assigned individual tasks, collected and analyzed information, and created concept maps. Ill-structured scenarios were given throughout the semester to PBL groups. Effectiveness of the method was tested through assessments and surveys. While students agreed that the instructional method was effective for teaching a real life application, students believed the assessments were based more on recall of facts than problem solving abilities. Therefore, either the activities were not appropriate for learning facts, or the assessment needed to be changed to measure what was actually learned.

Kenny, Bullen, and Loftus (2006) provided students with online PBL activities based on ill-structured case studies. The researchers evaluated the discussion posts from students. Two-thirds of the posts were categorized as demonstrating problem formulation and knowledge, whereas less than one-third demonstrated problem resolution. The authors concluded that the PBL activity was not completed because there may have been too much structure surrounding the PBL process since it was related to a specific assignment grade. Again, the assessment may not have been appropriate for the task, which may have stunted the activity's process.

Chung and Chow (2004) gathered feedback from students about their PBL experiences. Based on the feedback, the researchers redesigned PBL curriculum. Changes included reducing the number of problem cases given to students, progressively increasing the complexity of cases, and aligning assessment methods with learning objectives. The adjustments in assessments resulted in improved performance on those assessments.

Based on a review of previous studies, Norman (2001) examined the problem with types of assessments in PBL activities. It was important to test the acquisition of problem-solving skills, but it was also necessary to test for knowledge. Norman suggested the use of multiple choice questions for facts but use projects to show problem solving skills. The issue was that standard exams force instructors to teach to the test. Norman concluded that instead of giving one or two tests, progress tests given throughout the semester may be more effective.

This research showed that there have been difficulties assessing student knowledge and skills after completing PBL activities. Since the information collected and conclusions reached may not have included all facts found in multiple choice or true/false test questions covering the subject matter, those types of tests may not accurately measure the skills students learned during the activities. Alternative suggestions included using smaller progress tests, assessing skills when given a complimentary activity, or dividing lessons between PBL activities and other instruction to ensure that problem solving skills and subject matter facts have been learned.

Conclusion

PBL is an effective technique for teaching problem solving skills for complex problems. The body of research on PBL described here provides key guidelines for implementing PBL based on these attributes: ill-structured problems, small groups and interaction, time constraints, guidance, resources, and assessments. Ill-structured, authentic problems encourage students to work to find solutions; however, instructor guidance is needed to ensure students search for appropriate resources and focus on relevant information. Guidance can include providing a list of resources, worksheets, and timely feedback. Students also need help communicating and collaborating with others in groups and adhering to time constraints. Communication tools such as discussion forums and chatrooms must be in place when students are expected to work together online. In some studies, assigning roles to students helped students collaborate and complete activities (McLinden, McCall, Hinton, & Weston, 2006). Instructors can further assist students by providing feedback, hints, and constructive criticism while ensuring there is adequate time allotted for the activity. While providing guidance, it is important that instructors take on the role of facilitator instead of teacher to ensure the activities are learner-centered, which is one of the criteria for effective PBL. Finally, if assessments are necessary, they should test skills learned instead of specific facts since some of those facts may not have been uncovered during the students' exploration of information needed to complete the activity.

Structured Online Tutorials

Another method that can be used to teach students in online classes is through structured online tutorials. Tutorials consist of programs that range from simple step-by-step presentations of information to branching intelligent tutoring systems. While there are many definitions, the key features of effective structured online tutorials include: 1) clear information, 2) interactivity such as answering questions or moving objects, 3) immediate feedback, and 4) the ability to replay or skip portions (Silver & Nickel, 2007). When users can control segments of the tutorial, they determine what order to study the material, what material to skip, and what content needs more attention. Before the Internet was as far-reaching and accessible as it is today, tutorials were often created and packaged on disks and CD's or provided via dedicated instructional platforms and networks. Regardless of how students access the tutorials, students engaging in interactive tutorials often learn material better than if students have traditional instruction such as reading textbooks and/or listening to lectures (Silver & Nickel, 2007). The research presented in this section shows the effectiveness of structured online tutorials and is divided into the following topic areas: cognitive load, amount of interactivity, guidance and feedback, and motivation.

Cognitive Load

Cognitive load is the amount of mental energy being used in working memory (Sweller, 1988). Mayer (2002, 2003, 2013, & 2014) focused on issues with cognitive load as they pertained to his research to enhance his multimedia design of tutorials. He wanted to ensure that tutorials could be successfully completed without students encountering cognitive overload. Some of the factors included amount of material presented, speed of presentation, and effective use of mixed modes.

Mayer and Moreno (2002) examined the cognitive theory of multimedia learning through the use of animation and narration. Visual and verbal materials provided the opportunity for dual coding because information was provided in two different perceptual systems. If text with pictures was used (no audio), there was too much information on one mode, which increased cognitive load. When the participants were given audio and visual together, this distributed the cognitive load between two systems, allowing participants to process the information more effectively than if the audio and visual were presented one after the other.

Continuing their studies, Mayer and Moreno (2003) worked on methods to reduce cognitive load with multimedia. They determined that while giving choice of modality was good, to reduce overloading visual systems, it was best to move text to auditory so users could view pictures and hear the explanations. However, it is possible to overload both visual and auditory systems, so it is best to add time between slides so information can be processed. Finally, it is necessary to weed out extraneous information, so text and graphics should be aligned properly and redundancy should be reduced.

Issa, Mayer, Schuller, Wang, Shapiro, and Dakosa (2013) verified Mayer's evidence-based principles of multimedia design. They provided participants with regular PowerPoint then re-designed the slides to reflect Mayer's principles. Participants performed much better with the re-design. Within those new slides, pictures were added and extra text was eliminated. They converted text-based slides to visual representations with flow charts, arrows, and brief phrases. When users needed to retain information from one slide to compare and contrast information on a second slide, the two slides were combined to show comparisons side-by-side.

These studies' key points indicate that amount and mode of information presented are critical. It is important to ensure that each page or slide does not have too much content or any extraneous information to prevent cognitive overload. A blend of audio and visual is best; however, it should be noted that the designer must provide text as well for accessibility and technology issues (Quality Matters, 2013). Additionally, allowing users the ability to control the speed of the information gives them time to digest material before moving to the next block of information.

Interactivity and Multimedia

Working in tandem with cognitive load is interactivity. This can include the ability to click on and/or drag items, control video player, select pages to view, and even skip pages. Knowing how much interactivity to have in a tutorial can impact students' ability to learn the material being presented. Another important factor is use of multimedia. As indicated previously, mixed media can reduce cognitive load so students can process information more effectively (Mayer & Moreno, 2003).

Evans and Gibbons (2007) evaluated the effect of adding interactivity to tutorials. They adapted a study done by Mayer and Chandler (2001) that dealt with part-to-whole representation that affected cognitive load. Adding interactivity helped users control the pace and have time to assimilate the information. The researchers provided more interactivity by adding the ability to click for information and ability to control speed;

they added assessments and simulations where users needed to click to move objects. While the retention test results were the same as with the more passive group, the transfer test results were much better for those who received additional interactivity, indicating that interactivity may help with long term memory. This leads to a greater ability to apply information to new situations (Sweller, 1988).

To evaluate the effect of interactivity, Hulshof, Eysink, Loyens, and deJong (2005) created short tutorials to teach lessons in psychology. The tutorials were designed with experiential learning theories by Kolb. Two versions of the tutorial were created: one was text only, and the other included both text and interactivity. The interactive version contained pictures, ability to click on different pages, and graphical representations of data. Consistent with the results found by Evans and Gibbons (2007), while the control group (text only) performed better on the posttest, the experimental group (text and interactivity) retained more information when given the retention test.

In a study comparing single and multiple modes, all text or mix of text and graphics, respectively, Trey and Khan (2008) used pictorial presentations in tutorials along with scaffolding and small assignments to teach chemistry concepts. They used a three-step approach: generate model, evaluate, and modify. Similar to the studies described above, those with the pictorial representations performed better than those who were given tutorials with text only.

Espey, Ogburn, Kalishman, Zsemlye, and Cosgrove (2007) examined attitudes towards structured tutorials versus regular tutorials for anatomy lessons. The structured tutorial condition were given review cases, then articles to read and critique. Structured tutorials offered interactivity, but students had no control over order of topics, nor were they able to skip pages. After completing the tutorial, students gave presentations on key concepts of each week's topics. Researchers also integrated structured assignments with group interactivity. Results indicated that the structured tutorials provided better direction and enhanced learning, and students preferred structured tutorials over regular, more flexible, tutorials.

While structured tutorials should give students a chance to learn actively, there may be a limit to how much interaction is beneficial. Kalet, Song, Sarpel, Schwartz, Brenner, Ark, and Plass (2012) assigned medical students to one of three types of structured tutorial modules: *Watch*, *Click*, or *Drag*. Students in the middle-level activity (*Click*) scored significantly higher on the posttest than those in the other two groups. Overall, students spent more time on task in the *Drag* group. While dragging was more interactive since it required more actions or input by the students, it may have been more distracting and detracted from learning the content. Additionally, trying to retain information during the interactivity may have resulted in cognitive overload, which reduced students' ability to learn the material.

Ausman, Kidwai, Munyofu, Swain, Dwyer, and Lin (2008) studied the effects of visualization to teach physiology of the heart. The control group was given illustrations. A second group was provided with illustrations and practice sessions. A third group used illustrations and practice sessions but was also given animation that illustrated the relationships and principles. Posttests included a drawing test, terminology test, and comprehension test. Participants in group two, performed better on all sections. This showed that illustrations with practice sessions was a more effective combination than providing only illustrations or adding animation to the illustrations and practice sessions. As with the previous study, too much interactivity was a disadvantage due to potential cognitive overload.

These studies indicate that there is a balance to the amount of interactivity that is effective. Too much interactivity may be distracting and cause cognitive overload; whereas, too little may not provide enough stimulation. As some studies suggested, learning facts for short term may not require much interactivity, but long term retention is enhanced when users can interact with the tutorial through controls and various activities.

Guidance and Feedback

Interactivity also includes guidance and feedback. Feedback can be given when a student answers a question. Variables for feedback include type of response, amount of information provided, and timing.

In a study with sixth grade science classes, Pedersen and Liu (2002) examined the effect of different types of "expert" tools used in a computer program as the setting to solve problems. Three versions of support were used: 1) modeling (the expert modeled two general tasks—tool functionality and cognitive process during problem solving activities), 2) didactic condition—provided information about tool functionality and offered tips and examples of strategies but not specific to task, and 3) help—tool functionality only. In the post test, those who received modeling performed better than those who received the other versions. The results showed that the students needed the guidance provided in the modeling version.

Koedinger and Aleven (2007) examined the balance between giving and withholding information and assistance to optimize student learning. Three types of feedback were given (yes/no, feedback with goal information, and hints). Based on a meta-analysis of achievement tests from many researchers and educators using this tutorial, it was found that providing simple yes/no feedback was more effective than providing no information. Feedback with goal information was better than yes/no feedback and was better than simply pointing out errors. The tutorial also provided hints. Hints on demand were more effective than hints that popped up. Therefore, the interactivity of clicking for hints gave students control over their learning and presented information when the students were ready to receive it, while pop ups may have been too distracting, which may have resulted in cognitive overload because students were not ready to absorb the information presented. Feedback that showed the end result helped students learn the material more effectively than any other type of feedback presented (simple yes/no or showing errors).

These studies provided information on amount and types of guidance and feedback to use with tutorials. It is important to offer enough feedback without giving too much information that may be confusing for the student. Also, giving students control over when to receive feedback helps prevent cognitive overload.

Motivation

In order for students to learn the material presented in structured online tutorials, it may be necessary for students to view the tutorials multiple times or spend a fair amount of time learning the material presented. Motivation is a key factor in ensuring students spend the time needed to complete the tutorial and understand the information.

While Mayer conducted a lot of research to refine his evidence-based principles, he then examined what motivated students to complete tutorials and learn the materials. He determined that adding positive emotional design through colors and humanizing elements such as round face-like shapes resulted in better performance on posttests. However, adding irrelevant designs and graphics were too distracting. Ensuring that added effects were in proportion and appropriate resulted in better performance by the users (Mayer, 2014). It can be concluded that creating a tutorial that is attractive and enticing encouraged participation.

Schublova (2008) examined the use of different types of computer simulation programs to measure students' self-directed learning. The simulation that resulted in the highest scores was one that included a practice exam of an actual exam students were planning to take. It was concluded that its relevancy motivated students to participate more and score better on a posttest than when they used other versions of the simulations.

Based on these studies, ensuring the tutorial is relevant to the user is critical. Also, providing positive feedback, consistent design, and appropriate graphics are important.

Conclusions

The research on structured online tutorials reviewed here showed many situations in which tutorials were effective. In structured online tutorials, students should have the opportunity to test and re-test themselves, while reviewing materials as often as needed.

Tutorials should have an appropriate level of interactivity and structure, while giving students the ability to select the order in which they want to learn the material. Constructive feedback is also an important component of an effective tutorial. Additionally, each page or slide should have limited amounts of information to prevent cognitive overload. When students control the speed at which each page is shown, have the ability to review pages already seen, or select when to receive feedback, students are better able to process the information.

Attitude Towards Group Learning

Attitude towards group learning refers to whether a person prefers to work with others or alone (Kolb & Kolb, 2005). Students in this study were given one of two methods of instruction. PBL required students to work in groups and communicate with each other, while the structured online tutorial was designed for students to work independently. One of the research questions posed was if there was an interaction between method of instruction and attitude towards group learning. Even though the following research focuses on a relationship between learning style preference and achievement, others have found refuting evidence. After analyzing several studies about learning preference, Pashler, McDaniel, Rohrer, and Bjork (2008) determined that even though people may have had thoughts of how they preferred to approach learning, there was no evidence that preference made a difference in posttests or other assessments.

However, Pask (1979) came to a different conclusion when he reviewed research on learning style preferences. When students' learning styles were matched with the activity that complemented their learning styles, the posttest scores were much higher than when they were mismatched.

Many studies have been conducted to examine learning style preferences in relationship to teaching strategies. Mestre (2010) described different types of learners based on Kolb's Learning Styles model (Kolb & Kolb, 2005). Each person is evaluated along continuums of extremes on four different characteristics: active/reflective, sensing/intuitive, visual/verbal, and sequential/global. Focusing on the active/reflective continuum, active learners prefer hands-on activities. They enjoy group work and have difficulty sitting through lectures. At the other end of the spectrum are reflective learners. They like to think about the material before doing anything with it. Reflective learners prefer to work alone.

Mohr, Holtbrugge, and Berg (2012) examined Kolb's learning style theory by giving participants one of three forms of e-learning tools: interactive, non-interactive teacher-centered, and non-interactive learner-centered. The interactive tool included discussions, chats, and feedback during tutorial sessions which was more effective for participants who were more concrete learners and preferred to work with others. The non-interactive teacher-centered approach included audio/video recordings. These were better for students who were more reflective instead of active and preferred to work independently. The non-interactive learner-centered approach incorporated multiple choice quizzes and web assignments. This approach was moderately effective for both types of students, but for different reasons. Students who were more active preferred this over the teacher-centered approach because it presented a level of interactivity.

However, it was also effective for those who preferred to work alone since those students could interact with the material and not with people. This gave those learners an opportunity to observe and gather information independently.

Choi, Lee, and Kang (2009) also used Kolb's Learning Style Inventory to assess the impact learning style preferences had on success with a PBL activity given to anesthesiology students. Results showed no significant differences. Students were grouped so that there was one student from each learning style within each group. This methodology may well have diluted the impact of any particular learning style. Students who preferred working alone could gain information by reading posts from or listening to others without actively participating. On the other hand, it may be that preference did not have an impact on achievement.

Cook, Gelula, Dupras, and Schwartz (2007) compared posttest scores in a database table construction assignment given to medical students. Students were evaluated on the active to reflective continuum of the Kolb Learning Style Inventory. While there were no significant differences in the posttest scores, active learners preferred the table construction activity, and reflective learners preferred to work with a provided table (Cook, Gelula, Dupras, & Schwartz, 2007). Those preferences illustrated that active learners enjoy hands-on activities, while reflective learners like to take in the information before acting on it (Kolb & Kolb, 2005), even if preference does not impact posttest scores.

Gardner and Korth (1998) also gave Kolb's LSI and followed up with a survey to a group of business students to examine effectiveness of teams. Those who were accommodators (active) preferred group work, while assimilators (reflective) preferred working alone. It was concluded that students who were classified as active learners had a more positive attitude towards working in groups, while those who were reflective were able to participate in groups but did not prefer to do so.

Tsai (2011) created a hybrid e-learning model to accommodate student learning styles. He gave students a learning style inventory, then gave each student a customized learning map based on his/her style. One of three types of instruction was assigned to each student. *E-comprehension* was scenario-based and had tutorials and links to other information. *E-illustration* provided flowcharts and illustrated multimedia web pages. *E-workshop* allowed for communications through discussions and presentations. It was found that providing materials in different ways helped students succeed in the class because they could learn the material in a format that matched their learning style preference (Tsai, 2011).

Memletics Learning System was designed to help improve people's learning skills and mental fitness (Memletics High Performance Learning, 2015). Part of the process is to determine learning style preference. The learning styles inventory consists of 70 statements that are grouped into seven categories: visual, aural, verbal, physical, logical, social, and solitary. According to Memletics, understanding one's learning preference leads to using dominant styles or improving capabilities with other styles and enhances learning (Memletics High Performance Learning, 2015).

Shelton (2010) used Memletics Learning Style Inventory in conjunction with VARK (another inventory used to measure learning styles) to study preferred learning styles of seventh grade students. The goal was to teach students to use their learning style strengths to increase retention and understanding. While surveys were administered and students were given the results, the teachers in this study needed more information about individual students and how to adapt instruction based on learning style preferences. A recommendation was suggested that teachers should be evaluated to determine if their teaching styles corresponded with their preferred learning styles and with those of their students. Based on this study and Memletic's goal of using preferred styles or building weaker styles, there is no conclusive evidence that learning style preference makes a difference. Those in the active-reflective continuum can adapt to different situations in order to learn the material.

While there is no conclusive evidence that attitude towards group learning impacts achievement, based on studies that examined learning style preferences, different types of learners prefer to approach learning in different ways. Those who are active learners tend to take in the big picture then move to the details. They tend to be more social and will seek interactions with others. Those who are reflective learners work step-by-step and examine the details before they can look at the big picture. They prefer to work alone and like to think things through before telling others about their discoveries. Given the opportunity, students may gravitate towards the method of instruction that corresponds with the preferred learning style. The benefit of this is that students will feel more comfortable and more satisfied with the course, which may motivate students to work harder to learn the material.

Instructor Monitoring Methods

Instructor monitoring refers to ways in which instructors interact with students. The following research focused on types of student-instructor interaction, quantity of interaction, and the impact these have on student learning.

Student-instructor interaction includes all types of communication between the student and the instructor such as email, discussion posts, meetings, lecture, and feedback on papers. Student-instructor interaction, along with prompt instructor feedback, is a key factor in student satisfaction in online courses. When students feel more involved with the instructor, they are generally happier with the course. Student-instructor interaction correlates with student success (Tayebinik & Puteh, 2013).

Trujillo, Saseen, Linnebur, Borgelt, Hemstreet, and Fish (2014) tested pharmaceutical students' performance on evaluation questions after both student- and instructor-directed learning in online discussions about case studies. Students performed better on the test questions with instructor-directed learning. It is determined that there were more written assignments in the instructor-directed learning which gave students practice for the written part of the exams. Also, with instructor-directed learning, guidance was more consistent and covered all information needed to be learned.

While the above study illustrates positive effects of student-instructor interaction, Bye, Smith, and Rallis (2009) found the opposite to be true. They compared satisfaction and achievement in online discussions with peers with one-time feedback from the instructor. Half of the students posted reflections on readings in an online discussion while the other half submitted hard copy of those reflections to the instructor. In the online discussions, students responded to posted reflections with reflective and thoughtful comments. Students were able to engage in conversation about their papers both online and face-to-face. For the students who turned in their papers to the instructor, the instructor provided written feedback, and students were not able to talk with the instructor about the paper. Students in the online discussion group rated their mastery of course objectives higher; although, there was no difference in course grades between the two groups. It was concluded that students in the discussion groups were able to express their views with peers and engage in conversation in an attempt to understand what they could do to improve their papers; whereas the communication between instructor and student was more limited in the control group such that students were not able to ask questions and get additional feedback, as needed.

Since instructor presence appears to be a critical factor in designing an effective online course, it is important to determine the type of instructor feedback. Blignaut and Trollip (2003) developed a taxonomy of instructors' interactions in online discussions in college business classes. Their taxonomy included three academic categories: corrective (redirecting messages referring to student misconceptions and correcting erroneous statements made by students), informative (providing supportive feedback and weekly summaries), and Socratic (adding follow-up questions based on student posts to encourage reflection and more discussion) and three non-academic categories: administrative, affective, and misc. Results showed that instructors posted more non-academic than academic content. Corrective and Socratic were posted less often than any other type. While it is important to respond to students' questions and concerns and be supportive, it is also necessary for instructors to post open-ended questions to encourage student participation.

Gerber, Scott, Clements, and Serena (2005) examined the relationship between instructor stance (challenging versus non-challenging) and topic level (higher order versus lower order). The non-challenging stance elicited more responses from students; however, a greater percentage of posts that cited references, resulting in higher order level student responses were elicited when a challenging stance was used. These results were similar to those found by Blignaut and Trollip (2003), indicating that a combination of types of posts from the instructor may be required. These posts may be conversational, responding to student questions, providing feedback, or posing open-ended questions.

Nandi, Hamilton, and Harland (2012) also noted that student-instructor interaction was a critical factor in determining student satisfaction in an online course. They conducted a study with university-level online computer programming and IT courses. Weekly discussions were held with questions to elicit responses about course topics. Faculty also conducted live chats with students. Instructors gave feedback, answered questions, and provided five types of information: administrative, examples, direct answers, hinting, and feedback. Students were required to participate in discussions. It was concluded that discussions should be designed as a combination of both student-centered and instructor-centered. Both students and instructors then take responsibility to share ideas. Students receive guidance on what is expected, and instructors can alter their role according to student needs by providing guidelines, clarifying questions, promoting deep learning, providing direct answers and feedback, and promoting community building.

Muller (2014) analyzed discussion posts of three instructors. All three actively participated in online discussions. It was determined that balance was not with the amount of instructor posts but with types of posts. While the traditional approach has been a three-step process of initiation, response, and feedback, instructors should adapt based on student needs. Instructors should respond differently in situations where students do not respond versus students who appear to be capable of carrying on conversations without facilitation. Ultimately, the instructor's role should be that of facilitator to promote more conversation.

Esjeholm and Bungum (2013) examined teacher interaction with students in a robotics class. Two different types of interactions were identified: instructing by asking yes/no questions and more open-ended questions to allow students to work together to solve problems. Both were used depending on student needs at various stages. For example, when the groups began working on projects, students asked the instructor for help which was given in the form of direction answers. However, when students needed more help later, the instructor asked questions to encourage students to work through the problem. Again, different situations require different instructor interactions, such that there are times when students needs feedback to ensure students are making progress. Other times, students may be fine working with each other while the instructor monitors passively.

While the studies presented above illustrate various types of instructor-student interactions, the Community of Inquiry (CoI) model was developed specifically to address interactions in online learning. Garrison, Anderson, and Archer (2010) created the instrument to measure elements of this presence and their effectiveness in online learning. The model shows that learning is a result of three overlapping presences: teaching, social, and cognitive. Teaching presence includes clear communication of topics, goals, lessons, and expectations; teacher engagement in discussions and emails, and timely feedback; and the ability to keep students on task. Social presence includes communications and interactions with participants, ability to disagree in a trusting environments, and sense of collaboration. Cognitive presence includes stimulating problems to solve, interesting activities, and ways to test and apply knowledge. Teaching presence is essential to establish and maintain both social and cognitive presence.

In foundation courses in various graduate programs, Hosler and Arend (2012) used an adapted CoI Survey (Garrison, Anderson, & Archer, 2000) to measure student perception of teaching, social, and cognitive presence. Cognitive and teaching presence were perceived as more important than social presence. Students were more satisfied when instructors encouraged and supported deeper levels of critical thinking. Students also preferred instructors who interacted and provided timely feedback (Hosler & Arend, 2012).

While it is important to provide feedback and demonstrate expertise, students also need instructors to show their “human” sides. Similar to the CoI model, Bender (2012) noted that the role of teacher in online classes is four-fold: facilitator, expert, socializing agent, and person. As facilitator, the teacher is expected to encourage active participation. The teacher's role as expert is shown through lectures, documents, and discussion responses. As a socializing agent, the teacher writes letters of recommendation, helps students with research, and connects students to advisors and other key people. The role of person is exhibited by being compassionate and understanding. For students to gain knowledge, it is important to have discussions with feedback that lets students know how they are doing. It is also vital that the teacher personalize education and be responsive to each student. Throughout each course, instructors' roles may change based on the needs of the students.

Imlawi, Gregg, and Karimi (2015) examined impact of instructors' self-disclosures, use of humor, and credibility on engagement in course-based social networks. When instructors posted information about themselves that was related to the course or provided information or jobs related to the course, students' levels of motivation and course satisfaction were significantly higher. A balance of self-disclosure and course and content information is needed for students to interact with the instructor. This was illustrated in a study conducted by Sanchez, Martinez-Pecino, and Rodriguez (2011) to evaluate student perspective of the ideal professor. Students rated professors highest on teaching ability and professor-student relationships. These categories included professors who had good communication skills and were organized, respectful, and open.

Similarly, Hagenauer and Volet (2014) conducted a meta-analysis of studies regarding teacher-student relationships. Two dimensions were identified: affective and support. Affective included caring, which was regarded as beneficial by some and unnecessary or harmful by other researchers. Ultimately, there appears to be a balance in which faculty cannot get “too close” to students. However, faculty are deemed more approachable when they support students in their progress. Researchers determined that teacher-student relationships affect students’ success, course satisfaction, retention, learning, and achievement. More research needs to be done to determine optimal levels of support and affect that lead to higher teaching and learning quality.

In summary, student-instructor interaction is a key component in effective DL classes. Students are more satisfied with the course when the instructor’s presence is apparent. However, there is a balance that needs to be met that dictates the optimum instructor presence. Too little or too much presence results in lower levels of student participation, which could impact achievement. Research showed that students preferred instructors who demonstrated subject matter expertise, had good communication skills, and conveyed empathy. Studies also noted that type of instructor interaction should change based on needs of students. Interactions include providing feedback and guidance, eliciting higher-order responses, and personal anecdotes.

Summary

This body of research examined the effects of implementing different aspects of the main variables of this study. Variables were method of instruction (PBL or structured online tutorial), group preference (group or alone), and instructor monitoring (active or passive). Also included were studies illustrating methods used to teach complex problem solving, and particularly, relational database design.

When implementing PBL activities online, ill-structured authentic problems should be used. Students should be divided into small groups of 4-5 in which students are expected to use discussion forums or chat rooms to work together to solve the problem. Instructors should provide clear directions, including expectations and timelines. Guidance in the form of feedback and scaffolding may be needed to help students focus on relevant information and concepts. Resources may also be provided to give students more structure. Ultimately, activities should be evaluated by students and instructors to ensure students understand the process and results.

Structured online tutorials can also be used to teach problem solving. Each page or slide of the tutorial should contain facts and/or activities without adding extraneous information. It is recommended that both audio and text should be included so that students can process information in multiple modalities, preventing cognitive overload. Tutorials should have consistency, appropriate color and use of graphics, and some interactivity. Studies showed that too much interactivity was distracting and detracted from learning the material. Lastly, tutorials should be designed so that students have control over the speed of the information being presented, whether it is through clicking to change pages or providing video controls including pause and rewind. This gives students time to digest information before learning more. Students should be able to view the tutorial as often as needed.

Attitude towards group learning refers to whether students prefer to work alone or in groups. In PBL activities, students are expected to work in groups to solve problems. Structured online tutorials are generally completed alone. While the studies showed that people operate on a continuum between active and reflective (preferring group or solitude, respectively), there is no conclusive evidence that people cannot operate effectively in an activity that is opposite their preference. However, studies intimated that students may be more comfortable and may perform better when the method of instruction matched the learning preference.

Instructor monitoring is divided between active and passive (providing and withholding feedback, respectively). Studies illustrated that instructor presence and interaction is important for course satisfaction and student interaction. While student-student interaction is also needed, most studies indicated that instructor-student interaction was more critical. Instructor role needs to change with the needs of the students such that, at different times, the instructor may provide information, post questions, show empathy, or simply observe.

Many studies have been conducted that look at the use of PBL or tutorials compared with traditional instruction. To date, there have been few studies that compared the two approaches. Similarly, there are studies that have examined prior knowledge, or instructor monitoring methods, or learning style preferences. Unfortunately, there are no studies that have evaluated the interactions between these and their impact on learning problem solving skills. One common thread, though, has been the need for interactivity in web-based classes. However, since students have differing backgrounds, needs, and expectations, it is important to determine the best teaching approaches and types of interactivity to use for students in online classes.

CHAPTER 3

RESEARCH METHODOLOGY

Introduction

The purpose of this study was to compare the effects of problem-based learning, structured online tutorials, and instructor-student interaction on student achievement. Specifically, the research questions addressed included:

Is there a difference in achievement between students who engage in web-based problem-based learning versus structured online tutorials?

Is there a difference in achievement between students who receive active instructor monitoring vs those who receive passive instructor monitoring?

Is there a difference in achievement between students who prefer working in groups compared with students who prefer to work alone?

Is there an interaction between instructor monitoring method (active vs passive) and method of instruction (PBL vs structured online tutorials) in a web-based class?

Is there an interaction between attitude towards group learning and method of instruction?

Is there an interaction between instructor monitoring method and attitude towards group learning?

Is there an interaction between attitude towards group learning, method of instruction, and instructor monitoring method in a web-based class?

Subjects

Subjects selected for this study were 108 undergraduate computer technology and business majors from a large midwestern university. Students were enrolled in either the intermediate level or advanced level course and ranged in age from 18 to 60. Male students comprised 71% of the subjects and females 29%; 93% of the students were computer technology majors working towards their Associate or Bachelor degrees. Of those, 54% were concentrating on application development, while the remainder were divided between networking, Internet/multimedia, and generalist concentrations.

Students were selected for this study from three sections each of two courses. The courses consisted of intermediate and advanced computer applications. The intermediate level course focused on *Microsoft Excel* and *Microsoft Access*. A main emphasis of the intermediate level course was designing an effective relational database. The focus of the advanced level course was for students to work together in groups to complete projects for each software application. The course included projects that emphasized group learning methodologies for project management, problem definition, data retrieval and analysis, conclusions and recommendations. The prerequisite for the advanced course was completion of the intermediate level course or similar experience.

Treatments

Classes were conducted via *Blackboard Learn*. Students logged into the system to access their courses. Tools used in this course included: email, discussion boards, assignments, tests, web links, and groups. Tools were used to support the instructors' strategies and course objectives.

The facilitator was a full-time instructor in computer technology. She taught a variety of courses, including database design and *Microsoft Office* applications. The facilitator was given access to each class section by its instructor. The facilitator created a standardized set of assignments, tests, groups, and links within each class section in *Blackboard Learn*. A folder, which was added to the home page of each class section, contained links to each object. An email was sent to all students in the study explaining the purpose of the study and outlining tasks to be completed. Any student questions were answered by the facilitator.

Students were divided into groups by course section. One group received a PBL activity, and the other was given a structured online tutorial. Based on the research, the PBL activity consisted of an ill-structured problem that needed to be solved by collaborating and communicating in small groups (Reeves & Laffey, 1999; Hmelo-Silver, 2004). Discussion boards, chat rooms, file exchange, and email were provided to enable students to work together. The structured online tutorial was designed based on best practices uncovered through the research (Silver & Nickel, 2007; Mayer & Moreno, 2002). The tutorial contained several pages of information that students could learn at their own pace. Audio and video were used along with consistent layout, interactive quizzes with immediate feedback, and the ability to visit any page(s) desired. Students in the Active Monitoring condition group were given instructional feedback up to three times during the study, while students in the Passive Monitoring Group received no feedback at all.

PBL with Active Monitoring

Using the groups tool in *Blackboard Learn*, students were assigned to groups containing 4-5 students. Each group was given one of the PBL scenarios selected from Appendix A. An example of a scenario is: “Fred owns The Reading Nook Bookstore. He wants to keep track of customers, inventory, and sales. He would like to be able to send mailing and email blasts to customers. He also wants to create several reports: purchase details, books sold, number of customers, inventory lists with quantities on hand that are less than 5.” Students were instructed to use the discussion tool within their groups tool to work on the activity. They were expected to design a relational database including all tables, fields, and relationships based on the scenario given. Students were given three weeks to complete the assignment. The instructions are contained in Appendix B.

In order to complete the activity, students had to determine types of information to include in the database, including which fields belonged in which tables and relationships between tables. Guided questions were provided to assist students in creating primary keys (unique identifiers) and using foreign keys to link tables together.

The facilitator monitored each of the discussions, asking questions and adding clarifying statements to provide assistance.

The treatment lasted approximately 3 weeks. During that period, each student received up to three email messages from the facilitator. These messages included general encouragement and feedback on work completed. Examples included: "I see that you have not participated in your group's discussion. Read through the posts and add to the discussion by listing fields that should be in one of the tables;" or "Good job in your group's discussion. Your posts are on target."

PBL with Passive Monitoring

As with the PBL with Active Monitoring group, subjects were assigned to groups containing 4-5 students and each group was given one of the PBL scenarios. Students also used the discussion tool within their groups tool to work on the activity and were expected to design a relational database. Additionally, students received guided questions and were given three weeks to complete the assignment.

However, in this treatment, no additional feedback was given during the 3 weeks. No email messages were sent to students by the facilitator.

Structured Online Tutorials with Active Monitoring

Students in this treatment completed a structured online tutorial on database concepts. Students had three weeks to complete the tutorial. This tutorial provided students with definitions, examples, and quizzes. The tutorial was self-paced, and users could jump to different topics and revisit sections as often as desired.

Students were instructed to visit the online tutorial to help them learn how to create an effective relational database. Students were told that the tutorial was not timed, no information about its usage was recorded, and they were free to visit the website as often as they wished. The instructions to the students are shown in Appendix B.

The tutorial started with an introduction, then moved to the main menu. Links to activities and information included: *Module Objectives, Terminology, Table Creation, Quiz on Tables, Data Types, Quiz on Data Types, Relationships,* and *Final Quiz*. Each page had links to next and previous pages along with a link to the Main Menu page. The tutorial was self-paced and provided immediate feedback. The content of each section is detailed in Appendix C.

As with the PBL with Active Monitoring group, during the study, each student received up to three email messages from the facilitator that included general encouragement and feedback on his/her work.

Structured Online Tutorials with Passive Monitoring

Similar to the Structured Online Tutorials with Monitoring group, students completed a structured online tutorial on database concepts and had three weeks to view the tutorial. In this treatment, the facilitator noted time spent with the tutorial and was available to answer questions students had. However, no email messages were initiated by the facilitator.

Dependent Measures

Since the subjects had varying experiences with databases and were assigned to treatments by section, pre-tests were given to determine baseline scores and to ensure that there were no significant differences between the students. After their assigned treatment, students were given post-tests to determine their acquisition of skills designing a relational database.

Pre-test

The pre-test consisted of 3 true/false and 7 multiple choice questions. The questions focused on database concepts (see Appendix D). Example items include, Multiple Choice--"A ____is composed of fields and records" and T/F—"You need to save the database when adding or editing data." Questions were adapted from a test bank for "Practical Computer Literacy" textbook (Parsons & Oja, 2014). The textbook is IC3 certified ensuring that it contains lessons and assessments that are needed for the digital literacy certification test. It is also affiliated with SAM (Skill Assessment Manager), which contains online assessments and activities to ensure students are learning the skills being taught. SAM is software that is used to teach and test computer application skills. A study conducted by Cengage Learning found that 82% of instructors and 81% of students identified SAM as a key component in preparing students to use *Microsoft Office* applications (Cengage Learning, 2013). Within this study, the pretest was found to be reliable (α=.724).

Post-test

For the post-test, students were given one of the scenarios in Appendix A for which they were expected to design a relational database. Students who received the PBL treatment were given different scenarios for the post-test than they had for the PBL activity. Student responses were judged on a 15-point rubric (see Appendix E) that quantified the number of errors made based on tables used, fields included in each table, and the relationships between the tables, thereby ensuring rater reliability. To establish concurrent validity, the post-test was given to a database design class, who were then expected to create their own relational database. There was a correlation between the two activities, $r=.33$, $n=10$, $p>.05$. Construct validity and reliability were also measured by comparing the posttest results with the subsequent activity ($\alpha=.609$). Directions to the students were as follows:

> Based on the information presented in the following situation, design an effective relational database. You are responsible for listing the tables, fields within each table, and relationships between the tables. No data is needed. You can use any application to complete the assignment: Word, Excel, Access, Visio, or PowerPoint. Please complete the task without help from any other person or resource. Just do the best you can with the knowledge you have. Attach the document to this assignment to submit it.

Attitude Towards Group Learning Questionnaire

The Memletics Styles Questionnaire was a 70-question survey that evaluated learning style preferences on several dimensions. Ten questions that related to whether a person prefers to work individually or in groups were used for this study. One multiple choice question was shown at a time in an online assessment tool. The questions consisted of three choices: 1) “the statement is nothing like me,” 2) “the statement is partially like me,” or 3) “the statement is very much like me.” Examples of the statements include “You have a personal or private interest or hobby that you like to do alone,” and “You enjoy learning in classroom style surroundings with other people. You enjoy interaction to help your learning.” The full survey is contained in Appendix F.

Yong (2014) administered Memletics Learning Styles Inventory to preservice teachers enrolled in a science education program. Yong tested the validity and reliability of the instrument in a pilot study. The reliability was assessed through internal consistency using standardized alphas. The alphas ranged between 0.54 and 0.72, and the discriminant validity ranged between 0.17 and 0.23 for the seven scales. Elimination of questions reduced the total number of questions from 70 to 42 with six questions pertaining to each of the seven scales. Reliability then ranged from 0.56 to 0.75, and discriminant validity ranged from 0.13 to 0.21. In this study, comparing the scores with verification from subjects showed that the inventory was very reliable (10 items; α=.86).

Procedures

For the duration of the study, four to five sections of each of two courses were asked to participate. During the 7- or 15-week courses, 2-4 weeks were devoted to teaching *Microsoft Access*. Classes were assigned one of two types of instruction: problem based learning activity or structured online tutorial. Students also had access to textbooks and any online tools offered by the publishing company. The focus of the lesson was to teach students how to create an effective relational database.

The facilitator worked with instructors to develop lessons and instructions. Instructors gave the facilitator access to their online courses. To encourage participation in all facets of the study, students were given up to 30 extra credit points out of 300 class points for completing the four tasks of the study. Scores on tests had no impact on the amount of points each student received.

Before lessons began, students completed the pre-test, found in the extra credit folder on the home page of each class section. Students were instructed to do the best they could without any help or resources and were told that scores had no bearing on course grades. Students were assigned to treatment group by class section. Each class section received instruction based on the treatment matched to that section. Half of the sections completed a problem based learning activity, while the other half was given a structured online tutorial. Students were able to use textbooks, tutorials, and other information provided by the publisher. For students receiving active monitoring, each student received up to three email messages from the facilitator during the treatment time. The study lasted approximately three weeks for all groups.

At the end of the study, all students received the post-test and a survey. The posttest consisted of a scenario for which students were expected to create a relational database. A 15-point rubric was used to evaluate the posttest activity.

The 10-question portion of the Memletics Styles Questionnaire was given to each student in the study. Students had one week to complete the questionnaire. Upon completion of the questionnaire, the facilitator analyzed the results and emailed each student his/her attitude towards group learning profile. Once the questionnaires were complete and data and files were downloaded, the facilitator did not enter the online classrooms again.

During the study's duration, each course section's instructor also required other work to be done by the students. Some tasks included creating forms, queries, and reports for existing *Microsoft Access* databases.

Experimental Design and Data Analysis

This study used a 2x2x2 factorial design. Independent variables were: 1) type of instruction (PBL or structured online tutorial), 2) instructor monitoring method (active or passive), and 3) attitude towards group learning (working with groups or individually). The dependent measure was difference between pre- and post-test scores.

To determine the impact the variables had on the test scores, an analysis of variance (ANOVA) was used. Student scores on a concept pretest were used as the covariate. Independent variables were type of instruction (PBL versus structured online tutorial), attitude towards group learning (group work versus working individually) and instructor monitoring (active versus passive). Post hoc multiple comparison analysis of post-test scores was performed with the Neuman Keuls multiple comparison procedure.

CHAPTER 4

RESULTS

The purpose of this study was to compare the effectiveness of two modes of instruction when teaching a complex topic in an online course. Additional variables included instructor monitoring and attitude towards group learning. Students were given the task of designing a relational database after learning the material through a structured online tutorial or a problem based learning activity. Some students received active instructor monitoring while others received passive monitoring. Attitude towards group learning was determined via a 10-question survey adapted from Memletics Styles Questionnaire to evaluate whether students preferred to work individually or in groups.

Participants in the study were computer technology or business students taking online courses that included a section on relational databases. As part of their coursework, students were expected to create forms, queries, and reports. Students were offered extra credit points and money as incentives to complete the study activities. Nine classes, totaling 108 students, were asked to participate in the study. All students were given a pretest that focused on database terms and usage. They were also given a 10-question learning styles preference survey. Five of nine classes completed a structured online tutorial that provided information, practice activities, and feedback. The other four classes were given problem-based learning (PBL) tasks. Students in the PBL classes were split into groups of 4-5 students and given a scenario involving designing a relational database. All students were asked to complete a posttest in which they designed a relational database based on a scenario. Out of the 108 original students, 44 students completed all of the tasks.

To examine each of the research questions, a 2x2x2 factorial design was used. Independent variables were: 1) type of instruction (PBL or structured online tutorial), 2) instructor monitoring method (active or passive), and 3) attitude towards group learning (working with groups or individually). An analysis of variance was conducted in which the dependent measure was difference between pre- and post-test scores. The initial compilation of data showing means of pre- and post-test differences, standard deviations and number of subjects for each variable and variable combinations is illustrated in Table 1.

Table 1

Mean Scores for Difference between Pre- and Post-Test Scores in Each Level of Interaction

				Instructional Method		
				PBL	Tutorial	Total
Instructor Interaction	Passive	Group Preference	Social	M=0.60 n=5 SD=2.702	M=-0.17 n=6 SD=2.639	M=0.18 n=11 SD=2.562
			Solitary	M=1.00 n=1 SD=0	M=0.78 n=9 SD=4.549	M=0.80 n=10 SD=4.29
			Total	M=0.67 n=6 SD=2.422	M=0.40 n=15 SD=3.814	M=0.48 n=21 SD=3.415
	Active	Group Preference	Social	M=0.33 n=6 SD=3.77	M=-2.17 n=6 SD=2.563	M=-0.92 n=12 SD=3.343
			Solitary	M=1.00 n=8 SD=1.309	M=2.00 n=3 SD=3.0	M=1.27 n=11 SD=1.784
			Total	M=0.71 n=14 SD=2.555	M=-0.78 n=9 SD=3.270	M=0.13 n=23 SD=2.881
	Total	Group Preference	Social	M=0.18 n=11 SD=2.562	M=-1.17 n=12 SD=2.691	M=-0.39 n=23 SD=2.981
			Solitary	M=1.00 n=9 SD=1.225	M=1.08 n=12 SD=4.122	M=1.05 n=21 SD=3.154
			Total	M=0.70 n=20 SD=2.452	M=-0.04 n=24 SD=3.593	M=0.30 n=44 SD=3.115

To examine the research question of an interaction between attitude towards group learning, method of instruction, and instructor monitoring method, an analysis of variance (ANOVA) was conducted with difference between pre- and post-test scores as the dependent variable. To examine the relationship between prior knowledge (pretest scores) and post-test scores, a Pearson product-moment correlation coefficient was computed. There was a positive correlation between the two variables, $r=.602$, $n=44$, $p=.000$. To eliminate the effect of prior knowledge, the difference between the raw scores of the two tests was used as the dependent variable. Independent variables were method of instruction, attitude towards group learning, and instructor interaction. The research about prior knowledge showed conflicting outcomes. Wood and Lynch (2002) showed that prior knowledge may inhibit learning; although, other studies (Wu, Lowyck, Sercu, & Elen, 2013; and Huang, Lin, & Huang, 2012) found that prior knowledge resulted in higher posttest scores. In this study, prior knowledge helped students perform better on the posttest; therefore, the difference between pre- and post-test scores allowed for the examination of gain of knowledge based on the treatment. Output for the ANOVA is shown in Table 2.

Table 2

Analysis of Variance

Source	Type III Sum of Squares	*df*	Mean Square	F	*Sig*
Corrected Model	53.404	7	7.629	.755	.628
Intercept	5.027	1	5.027	.498	.485
Instruct Interaction	.481	1	.481	.048	.829
Method of Instruction	2.730	1	2.730	.270	.606
Attitude Toward Groups	16.817	1	16.817	1.664	.205
Interact * Method	.115	1	.115	.011	.916
Interact * Attitude	5.364	1	5.364	.531	.471
Method * Attitude	7.208	1	7.208	.713	.404
Interact * Method * Att	3.849	1	3.849	.381	.541
Error	363.756	36	10.104		
Total	417.159	43			
Corrected Total	28319.727	43			

Levene's Test of Equality of Error Variance was not significant, $F(7,36)=1.867$, $p=.104$, indicating that the variance of the posttest was equal across groups. A graph depicting the mean difference between pre- and post-test scores for the interaction of all independent variables is shown in Figure 1.

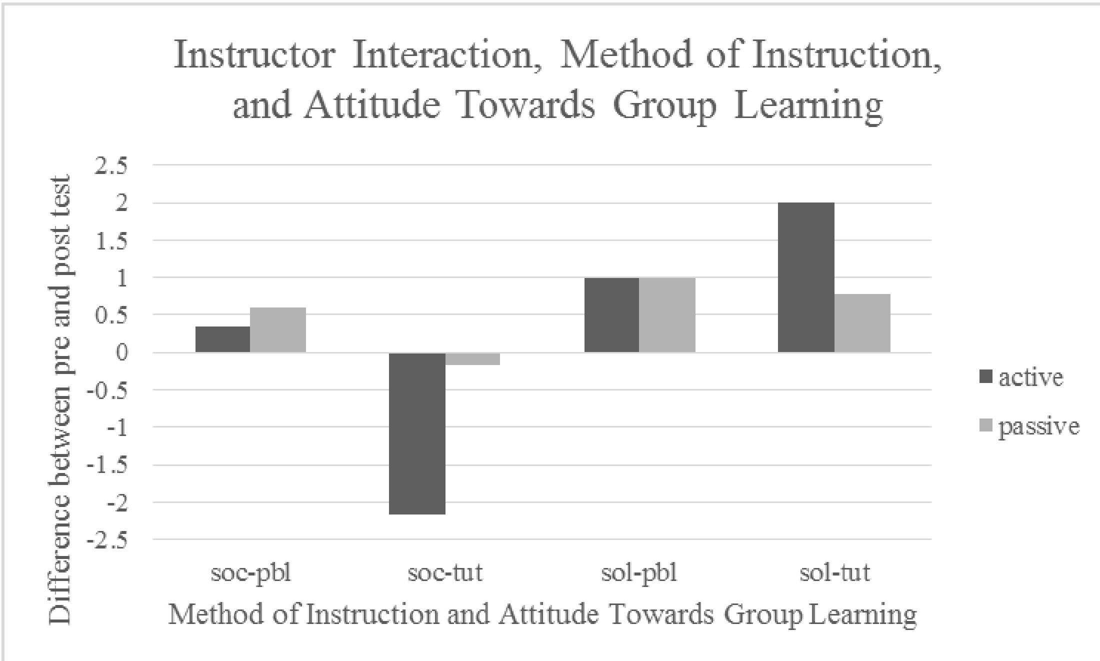


Figure 1. Mean difference between pre- and post-test scores for interaction of all independent variables.

This graph shows mean difference between pre- and post-test scores for each combination of variables: group preference, instructor interaction, and method of instruction.

Figure 1 shows that students who preferred working independently performed better than those who preferred working in groups, regardless of the activity. Interestingly, students who preferred working independently performed much better than those who preferred working in groups when given the tutorial compared with the difference between the two groups when given the PBL activity. As previously stated, results of the ANOVA were not significant for the main effect, $F(1,44)=.381$, $p=.541$.

The first research question looked for a difference in method of instruction, namely PBL versus structured online tutorial. While results were not significant, ($F(1,44)=.270$, $p=.606$) those engaged in the PBL activity obtained a higher difference between pre- and post-test scores ($M=0.70$, $SD=2.452$) than those who were given the structured online tutorial ($M=-0.04$, $SD=3.593$).

Previous research suggests that students who engaged in PBL activities performed better than those who were given traditional instruction (Barrows, 2002; Reeves & Laffey, 1999; and Rounds & Rappaport, 2008). Conversely, students who viewed structured online tutorials as supplemental instruction performed better than those who did not view the tutorials (Silver & Nickel, 2007). However, there were no studies that compared PBL with structured online tutorials. While not significant, students who were given the PBL activity performed much better on the posttest than those who viewed the structured online tutorial. There may be several reasons for this: students interacted with each other and could learn from each other in the PBL activity, students received feedback and scaffolding from the instructor within the PBL activity, and it is unknown to what extent students participated in the structured online tutorial. However, this result comports well with research showing that students were more engaged and more satisfied when instructors interacted with them (Tayebinik & Puteh, 2013 and Nandi, Hamilton, & Harland, 2012).

Overall, students scored higher with passive instructor interaction (M=0.48, SD=3.14) than with active (M=0.13, SD=2.881). Results from ANOVA were as follows: $F(1,44)=.048$, $p=.829$. Previous studies have indicated that student-instructor interaction results in higher student satisfaction in the course (Tayebinik & Puteh, 2013 and Nandi, Hamilton, & Harland, 2012). However, it has also been noted that too much or too little interaction inhibited student interactions and responses (Gerber, Scott, Clements, & Serena, 2005). In this study, active instructor interaction consisted of instructor email messages to the students that encouraged participation or gave constructive feedback. Since students also received feedback through discussions in the PBL activities, it appeared as if the emails had no impact or even a negative impact.

The fourth research question examined the difference between pre- and post-test scores based on attitudes toward group learning. Based on the 10-question portion of Memletic's Learning Style Preference Survey, students were found to prefer working in groups or working alone. While not significant ($F(1,44)=1.664$, $p=.205$), students who preferred working alone (M=1.05, SD=3.154) scored higher on the posttest than those who preferred working in groups (M=-0.39, SD=2.981).

Previous research has suggested that when students' learning style preference was matched with the right type of activity, students would perform better (Mestre, 2010 and Pask, 1979). Similarly, students who preferred working independently were able to perform well in groups by observing and gathering information (Mohr, Holtbrugge, and Berg, 2012). The results from this study indicate that those who preferred to work alone performed better than those who preferred to work in groups regardless of type of instruction. Since students who preferred working independently could gather information by viewing both the PBL activity discussions and the structured online tutorial, even if they did not actively participate, they were able to learn in either environment.

The interaction between instructor interaction and method of instruction was not significant ($F(1,44)=.009$, $p=.926$). Students who were assigned the PBL activity performed slightly better with active instructor interaction ($M=0.71$, $SD=2.555$) than with passive instructor interaction ($M=0.67$, $SD=2.422$), even though all students in the PBL activity had instructor interaction within the discussion forum of the activity. Conversely, students who were assigned the structured online tutorial performed better with passive instructor interaction ($M=0.40$, $SD=3.814$) than those with active instructor interaction ($M=-0.78$, $SD=3.270$).

In previous studies of PBL, instructors provided scaffolding to help students achieve the goal of the activity (An & Reigeluth, 2008), thereby engaging in instructor-student interactivity. That interactivity was also found in structured online tutorials where students felt the tutorial had a social presence because it gave feedback (Hardy, 2005). While in this study, instructor interaction was defined as emails sent or not sent to the students, other instructor interactions were present, which may have confounded the results. The instructor gave constructive feedback in the PBL activity, which was provided as needed. In the tutorial, the instructor provided programmed written feedback for activities and included a step-by-step tutorial with audio; however, there was no real-life interaction.

While there was no significant interaction between attitude toward group learning and method of instruction (F(1,44)=.713, p=.404), there was a large difference between students who preferred working with groups in the PBL activity (M=0.45, SD=3.174) versus the structured online tutorial (M=-1.17, SD=2.691). That difference in scores was much greater than for those who preferred to work independently (M=1.00, SD=1.225 versus (M=1.08, SD=4.122). The results are illustrated in Figure 2.

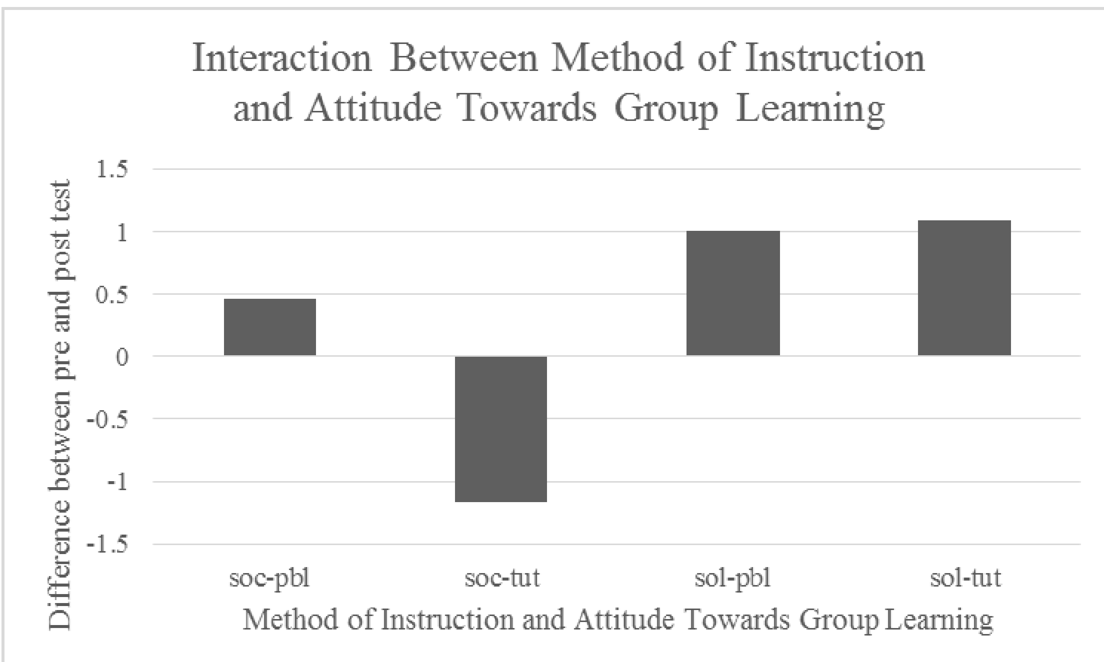


Figure 2. Mean posttest scores for interaction of attitude towards group learning and method of instruction.

These results support research that suggests that those who prefer to work alone can function equally as well with either task (Gardner & Korth, 1998). However, students who prefer working with others performed better when the task matched their preference (Pask, 1979). This was more apparent when those students were given the structured online tutorial and had to learn without the ability to work with others.

The interaction between instructor interaction and attitude towards group learning was not significant ($F(1,44)=.531$, $p=.471$). Students who preferred to work alone performed better with active instructor interaction ($M=1.27$, $SD=1.794$) than students who preferred to work in groups with active instructor interaction ($M=-0.92$, $SD=3.343$). For those receiving passive instructor interaction, students who preferred working alone ($M=0.80$, $SD=4.290$) performed better than those who preferred working in groups ($M=0.18$, $SD=2.562$), but the discrepancy was not as great as for those receiving active instructor interaction. The means are illustrated in Figure 3.

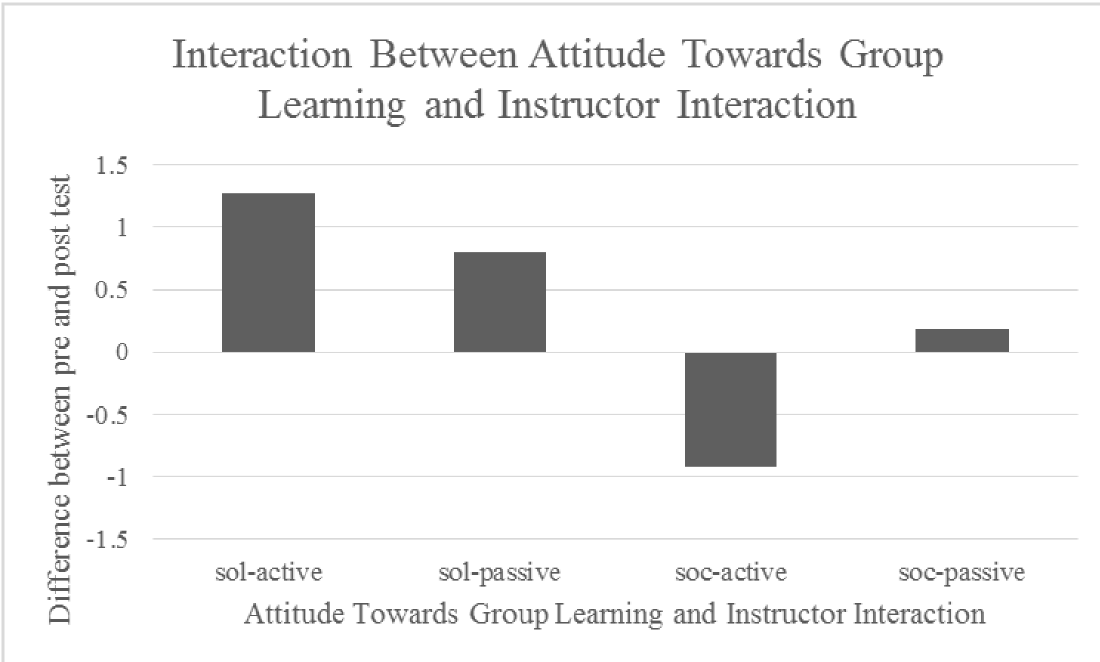


Figure 3. Difference between pre- and post-test scores for interaction between attitude towards group learning and instructor interaction.

While previous research showed that student-instructor interaction results in greater student satisfaction and success (Tayebinik & Puteh, 2013; Trujillo, Saseen, Linnebur, Borgelt, Hemstreet, & Fish, 2014), students were more satisfied with the course when instructors encouraged deeper levels of critical thinking (Hosler & Arend, 2012). In this study, email was sent to the students as instructor interaction, but the content of the email to students who engaged in the structured online tutorial urged students to visit the tutorial and email the instructor with questions. While students who preferred working in groups did not do as well, overall, those who did not receive emails from the instructor performed better than those who did. It is possible that they interacted with others to gather the information they needed to complete the activity and did not need instructor support. Bye, Smith and Rallis (2009) found that students preferred working with others instead of having limited interactions with the instructor.

Regardless of attitude toward group learning, the structured online tutorials ($M=7.17$, $SD=4.41$) were visited more often than the PBL activity ($M=3.35$, $SD=2.48$). Based on an ANOVA, this was a significant difference ($F(1,44)=9.751$, $p=.004$). The mean number of visits is illustrated in Figure 4. Students who preferred working in groups ($M=7.67$, $SD=5.40$) visited the tutorial more often than those who preferred working alone ($M=6.65$, $SD=3.31$). Conversely, those who preferred to work independently ($M=3.78$, $SD=2.54$) visited the PBL activity more times than those who preferred to work in groups ($M=3.0$, $SD=2.49$). Further analysis showed that students who preferred to work independently posted about every other time they visited the PBL discussion, whereas the students who preferred to work in groups posted every time they visited the forum. This trend supports the previous findings that suggest that students who preferred to work independently could visit the PBL activity discussion to gather information, even if they did not participate (Kolb & Kolb, 2005; Gardner, & Korth, 1998).

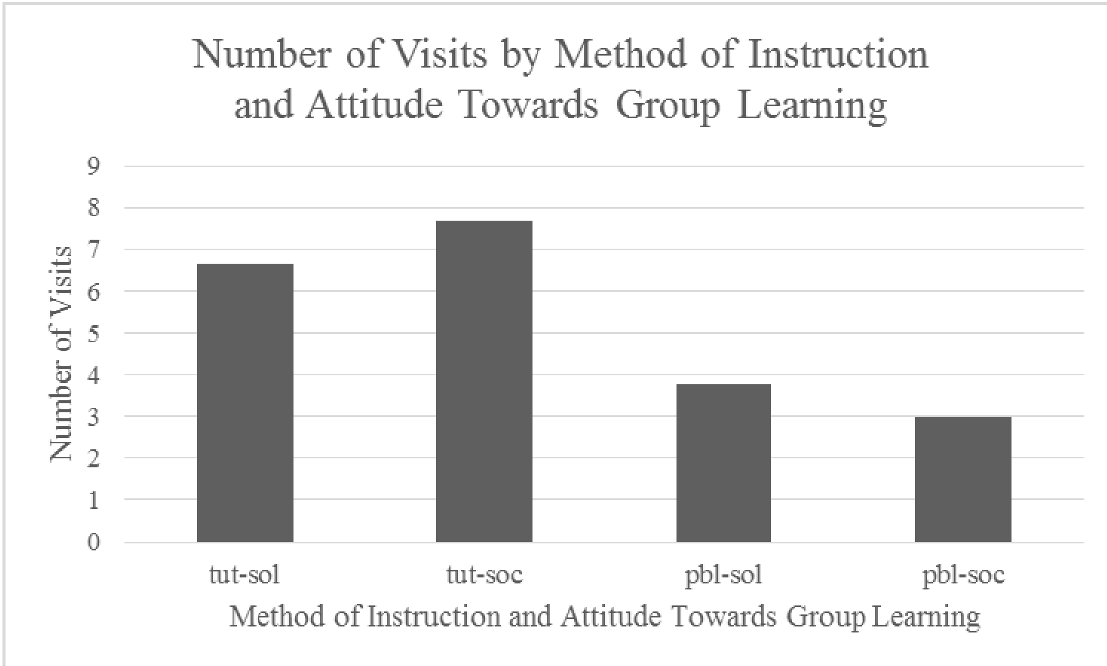


Figure 4. Mean number of visits for interaction of method of instruction and attitude towards group learning.

Summary

While there were no statistically significant findings in this study, there were several trends that strongly support previous research. Students who participated in the PBL activities scored higher on the posttest than those who viewed the structured online tutorial. Students who preferred to work independently scored higher on the posttest than those who preferred working in groups. Moreover, students who preferred working independently were better able to adapt to either method of instruction than those who preferred working in groups. Those students scored much lower on the posttest when given the structured online tutorial than the PBL activity, whereas the range of posttest scores for students who preferred working independently was much smaller. Instructor interaction did not seem to affect results by method of instruction or group preference. However, its impact could have been minimized since the instructor interacted with students in the discussions of the PBL activities and could only email about amount of participation with students completing the structured online tutorial. Overall, this data supports the value of providing students with activities that match their attitude towards group learning and increased student-instructor interaction, while suggesting that there will be varying degrees of each required for each student.

CHAPTER 5

DISCUSSION

The goal of this study was to compare different approaches to teaching complex topics in web-based courses. Specifically, this study compared structured online tutorial with problem based learning activity. In addition, this study compared type of instructor monitoring, either active or passive. The central hypothesis of this study was whether providing active instructor monitoring and matching students' attitude towards group learning (group versus independent) with method of instruction would result in improved posttest scores on a related activity. In this way, results of this study might be beneficial to educators charged with teaching complex topics in online courses.

Discussion of Research Question Results

Method of Instruction

The research showed that both methods (PBL and structured online tutorial) could be effective (Dominquez & Jaime, 2010; Murray & Guimaraes, 2009) for teaching relational database design. In these studies, as in the current study, students were allowed to use other resources. The extent of use of resources is unknown, nor can it be determined if that had an impact on the results.

Results showed that students engaged in PBL activities performed better on the posttest than those who were given structured online tutorials. However, the frequencies of tutorial use and participation in PBL activities did not correlate with posttest scores. In other words, the amount of time spent on the tasks did not seem to have an impact. It is possible that students who did well already understood the process and did not need additional instruction. In the PBL group, the facilitator provided guidance in the discussion by identifying redundancies in the database designs. The only feedback received in the structured online tutorial was programmed into the quizzes. No data was collected on how students engaged in the activities and lessons provided in the structured online tutorial. In short, a likely explanation for the superior performance of students in the PBL treatment is better just-in-time instruction. The structured online tutorial provided programmed feedback, whereas instructor feedback in the PBL activity was more dynamic and better able to address relevant issues and concerns.

While classes were divided evenly for method of instruction, many students did not complete all aspects of the study and were not included. The average score on the pretest for those given the PBL activity was 89%; whereas, the average pretest score for those given the structured online tutorial was 70%. While the difference between the pre- and post-test scores was used in the ANOVA, since the pretest scores were higher for those given the PBL activity, students were apt to do better on the posttest than those who were assigned the structured online tutorial. Students who did not complete all activities had an average pretest score of 68%. While the scores seem to indicate that students engaged in the PBL activity performed better than those engaged in the structured online tutorial, it is possible that there were important differences in the sub-population that elected not to complete all of the activities. Here, it is likely that those students had mastered the course content, had high confidence in their scores, and believed that extra credit was unnecessary.

Instructor Interaction and Method of Instruction

There was no significant difference in performance between students who received active monitoring and those who did not. Similarly, no significant interaction between instructor monitoring method (active vs passive) and method of instruction (PBL vs structured online tutorials) was found in this study. However, students who received active instructor monitoring with PBL activities scored slightly higher on the posttest than those who had passive monitoring. Conversely, students who were assigned the structured online tutorial and who received passive monitoring performed somewhat better than those who received active monitoring. Since active instructor monitoring for structured online tutorials was limited to comments about attendance rather than performance, the only benefit those students received was acknowledgement of their presence. Students who received emails from the instructor did not respond, so no conversations about the topic were pursued. Students in the PBL activities received feedback from the instructor through email but also through coaching and scaffolding within the online discussions. Therefore, those who received passive monitoring (no email messages) still gained from the interactions between the instructor and the students within the PBL activity and performed better on the posttest than those who were assigned the structured online tutorial.

While many authors have suggested that student-instructor interaction is critical in successful online classes (Bye, Smith, & Rallis, 2009; Blignaut & Trollip, 2003; Nandy, Hamilton, & Harland, 2012), few studies have measured its impact. Blignaut and Trollip (2003) analyzed types of instructor posts in an attempt to create a taxonomy of interactions. Garrison, Anderson, and Archer (2000) found that cognitive and teaching presence in which instructors encouraged deeper levels of critical thinking resulted in greater student satisfaction of courses. Research also suggested that type and quantity of instructor interaction were important for student satisfaction (Gerber, Scott, Clements, & Serena, 2005; Hosler & Arend, 2012).

However, there is little research that relates student success on tasks based on specific types of instructor interaction. More research needs to be done to determine the optimal level and type of instructor interaction for student success in online classes. Clearly, in this study, the type and frequency of feedback provided was not effective in improving student learning. Within the PBL activity, instructor feedback helped students successfully complete the activity; however, feedback for the structured online tutorial did not provide enough detail. To have a greater impact, the instructor must analyze the needs of the students, provide scaffolding, and promote critical thinking through student-instructor interactions. For future studies, the structured online tutorial must be designed so that the instructor can view student progress and remark on possible difficulties.

Attitude Towards Group Learning and Method of Instruction

Data from this study suggests that most students preferred to work in groups. Gardner and Korth (1998) found that those who preferred working in groups were happier doing so; however, those who preferred working alone could participate in group work but preferred not to. Results were similar between Gardner and Korth (1998) and this study: Attitude towards group learning did not seem to have an impact on scores. Students who preferred working independently performed better than those who preferred working in groups, regardless of the treatment.

In this study, there was not a significant difference within the PBL activity group between those who preferred learning in groups over those who preferred to learn independently. While not significant, slightly over half (55%) of all students preferred working with groups, and 45% preferred working independently. While those who preferred working in groups actively participated more often, students who preferred working independently scored better on the posttest, regardless of method of instruction. Students who preferred working in groups participated in PBL activity discussions every time they entered the activity ($M=3.2$, $SD=2.53$); whereas, students who preferred to work independently, actively participated in the discussion half as often ($M=2.8$, $SD=0.98$) as they viewed the posts ($M=5.17$, $SD=1.835$). Students who preferred working in groups performed much better on the posttest when given the PBL activity than the structured online tutorial; whereas, the difference for students who preferred working independently was not as great. Not surprisingly, students who preferred working in groups seemed to thrive when given group work and do poorly when given individual activities; whereas, students who preferred working alone were able to perform almost equally as well when given either activity. Those students appeared to be able to gather information needed to learn the skills regardless of how it was presented. The students who preferred working in groups may have needed more instruction and interaction. The ability to accommodate different types of learner preferences is one of the cited strengths of PBL (Barrows, 1996; Gremler, Hoffman, Keaveney, & Wright, 2000).

Pask (1979) found that students who prefer to work in groups assert that they often want and need help from others. The PBL activity included a platform within which students could interact with each other, whereas the structured online tutorial did not. This explains why students who preferred working in groups performed better on the posttest when given the PBL activity.

Previous research suggests that students who prefer groups tend to find ways to interact with others regardless of the prescribed learning activities (Pask, 1979). In this study, those students did not participate in the PBL activity as often as would have been expected. It may be the case that they were able to interact with others in different ways. For example, they may have met in person, emailed each other, or contacted others outside of the group. It is also possible that because they did not interact enough to be fully successful, they did not learn the material and did not do as well on the difference between pre- and post-test as those who preferred working alone ($M=-0.39$, $SD=2.981$ vs $M=1.05$, $SD=3.154$).

Students who preferred working alone were able to adapt to both activities and learn what was necessary in order to complete the posttest. Even though they would rather work alone, they could gather information from the PBL activity by reading others' posts without actively participating. While they may have used other sources, no data was collected to analyze the extent and type of resources used.

Instructor Interaction and Attitude Towards Group Learning

While there was no significant difference, students who preferred working in groups scored higher on the difference between pre- and post-test when receiving passive monitoring instead of active ($M=0.18$, $SD=2.562$ vs $M=-0.92$, $SD=3.343$). Since students were able to communicate with each other, they may not have needed feedback from the instructor. Observations during the study suggest the feedback may have encouraged more participation in the PBL activity or viewing the structured online tutorial.

As stated previously, the literature on feedback strongly suggests that the type of instructor interactivity is important. It is likely here that the feedback condition should be bolstered and contain more constructive feedback. In this study, it seemed that students did not care about the emails from the facilitator since she served as instructor only during the study and not for the entire course. Additionally, since the scores received on the study activities had little bearing on student grades, students were less likely to invest time and energy into the completion of the activities.

Method of Instruction, Attitude Towards Group Learning, and Instructor Interaction

There were no significant interactions between attitude towards group learning, method of instruction, and instructor monitoring. Students who participated in the PBL activity who preferred groups scored better with passive monitoring (M=0.60, SD=2.702 vs M=0.33, SD=3.777). Regardless of attitude towards group learning, students performed better on the structured online tutorial with passive than with active monitoring (M=0.40, SD=3.814 vs M=-0.78, SD=3.270). As stated above, students who preferred to work independently scored higher on the difference between pre- and post-test, irrespective of method of instruction, than students who preferred to work in groups.

Limitations of Study

While many students were invited to participate in the study, only forty-four percent chose to complete all of the activities. Students were offered extra credit and monetary incentives, but neither seemed to be adequate incentives to complete the study tasks.

Lei (2013) examined reasons why students did not complete extra credit assignments. Lei asserted that motivation often determined whether students will perform challenging work, especially extra credit that is completed voluntarily. The main reasons why students did not do extra credit work were: 1) extra credit points were not worth the time and effort, 2) not enough points were given to improve the final grade, 3) work was too challenging, and 4) students were burned out from all of the required coursework. In addition, students cited personal reasons such as illness and family obligations for not completing extra credit.

Harrison, Meister, LeFevre (2011) analyzed students' completion of voluntary extra credit and found that only 38% chose to complete assignments. Students in larger-sized classes participated in extra credit more than those in smaller-sized classes, and students with lower grades, who could have benefitted from extra credit, were less likely to complete the assignments.

In this study, there were four tasks that needed to be completed: pretest, attitude towards group learning survey, participation in structured online tutorial or PBL activity, and posttest. Eighty-five percent of students completed all activities except for the posttest, which prevented students from earning the extra credit. The posttest was the only activity that required independent problem-solving. Perhaps students did not want to expend the effort needed, ran out of time at the end of the semester, or were afraid to show that they did not understand how to do the task.

Implications of Study

Hancock, Bray, and Nason (2002) examined student achievement and motivation when exposed to instructor-centered versus student-centered instruction while learning computer applications. Students who were more independent and had a greater sense of self performed significantly better with student-centered instruction than those given teacher-centered instruction.

That could mean students who are able to work independently and think things through do not need as much instructor guidance as those who are more impulsive and dependent. While those characteristics were not evaluated within this study, they can equate to motivation and extra credit, partially explaining why so many students did not complete the activities presented to them. It also relates to students who preferred working in groups and needed more feedback from peers than they received, so their scores were lower than those who preferred to work alone. They seemed less able or less inclined to learn from the structured online tutorial since that required students to work independently.

Complex and abstract concepts require a base of knowledge and an ability to solve problems. In online college courses, there is generally a range of students with different prerequisite skills, experiences, and attitude towards group learning. Understanding how students learn is important when teaching new skills or enhancing existing skills. Providing lessons in which students can practice these skills in increasingly more complex situations will help students master the concepts. Incorporating different types of lessons within each course will help ensure that students who prefer group or individual tasks will be exposed to both methods. Providing scaffolding and guidance through feedback will also be beneficial.

This study examined the interactions between method of instruction, attitude towards group learning, and instructor monitoring. Dependent variable was the difference between pre- and post-test scores. While there were no significant differences, results suggest that 1) prior experience does impact learning whereby the students perform better with prior learning, 2) students may learn better with the correct type and amount of instructor interaction, 3) attitude towards group learning does affect students who prefer working in groups, and 4) a problem based learning activity is a better method of instruction than using a structured online tutorial.

Future Research

Further research needs to be conducted. In this study, students performed better when engaged in PBL activities than those learning through structured online tutorials. However, future research should examine ways to best capitalize on and enhance the interactions between students engaged in PBL. Data should be collected on the frequency and nature of their interactions.

Students who preferred to work independently scored a greater difference between pre- and post-test than those who preferred to work in groups during a group activity. In other words, despite their preferences, independent learners out-performed their peers. More research is needed to discover how these students approach group learning tasks while maintaining their own learning focus. In addition, scores on the selected portion of the Memletic's Learning Style Preference Survey were within one point of each other, thus making it difficult to determine, conclusively, if students actually had a preference. The instructor emailed attitude towards group learning results to each student and asked if the results were accurate. Students thought the results were correct, but group preference also depended on types of projects or tasks on which students were working. Perhaps a more robust measure of learning preference would be helpful in future studies to ascertain the attitude towards group learning of the participants and determine how critical this may be for students' success in different types of activities.

In this study, instructor feedback (active instructor monitoring) seemed to have little impact on achievement. The nature of instructor feedback in PBL warrants further examination. This study only examined whether the instructor provided feedback or not. Previous studies have shown (Gerber, Scott, Clements, & Serena, 2005) that too much feedback is as detrimental as no feedback at all. Providing praise, scaffolding, guidance, and constructive criticism should be studied in conjunction with method of instruction. Students who need reassurance that their answers are correct could benefit from constructive feedback or praise, whereas those who are more determined to figure things out independently may prefer a simple acknowledgement or no feedback at all. Providing the right type of feedback could help students learn the material so they perform better on activities and tests.

The role of prior experience also warrants further investigation. In this study, students who performed better on the pretest tended to perform better on the posttest. This result is not surprising since some students also received instruction on this topic in previous classes. Even though the main focus of previous classes was not on relational databases, these students had some experience creating databases. Specific research should be conducted to determine how many times students need to be exposed to complex concepts before they are able to be competent in the skills surrounding those concepts. In this study, it seems as if students with prior experience were less likely to fully participate in PBL activities. Strategies to engage these students should be developed and tested.

Students who were assigned structured online tutorials or PBL activities also had the ability to gather information from other resources (books, instructor, peers, videos, etc.) Of course, the use of these materials is generally desirable. However, the use of external resources is a contaminating influence in this type of study. A fuller depiction of the actual learning methods might be obtained through additional data collection techniques such as learning logs, think-aloud protocols, or systematic observations.

While providing different approaches to accommodate attitude towards group learnaing, further research needs to be done to better understand how students learn complex topics, especially in an online environment. Not only do students need to be able to learn concepts and complete activities, they need to be self-motivated, have good time management skills, and have the ability to learn independently to do well (Desai, Hart, & Richards, 2008). Providing lessons that help students gain those skills while teaching concepts would be highly beneficial.

For instructors who teach complex topics in online courses, understanding the needs of students and providing a solid combination of activities and feedback is critical. It can be concluded from this study that while additional research is needed, instructors should provide different types of activities that include various modes of learning to reach all students.

APPENDICES

APPENDIX A

SCENARIOS

APPENDIX A

SCENARIOS

1. Fred owns The Reading Nook Bookstore. He wants to keep track of customers, inventory, and sales. He would like to be able to send mailing and email blasts to customers. He also wants to create several reports: purchase details, books sold, number of customers, inventory lists with quantities on hand that are less than 5.
2. Jan owns EveryTool hardware store. She wants to keep track of customers, inventory, and sales. Also, she wants to create invoices, show what items have been sold within a given month, show how many customers purchased items, and have an inventory list sorted by the most popular items.
3. Sam owns Geek Toys computer store. He wants to keep track of customers, inventory, and sales. He would also like to generate reports showing inventory on hand, customers who have made purchases within a given time frame, and a list of customers' email addresses.
4. Becky owns MovieWatch (an online video rental store). She wants to keep track of customers, inventory, and rentals. She needs to create a report that shows each customer's current rentals with due dates (a customer can keep a dvd for 2 weeks). If a dvd is late, there should be a check mark showing on the report.
5. John owns Soothe Me Spa. He would like to keep track of customers, employees, and services. Each service for a given customer should indicate which employee

6. provided the service. John wants to generate reports showing how many of each service was provided, the number of services provided by each employee, and a list of the top 20 customers based on amount of money spent during a particular time frame.
7. Gus works in the IT department of Metallics, Inc. The production department needs a way to keep track of raw materials, finished products, and employee activity. Raw materials are ordered as needed to be used to form the products. Employees are all cross-trained, so they can work on any part of the assembly. The manager of production wants to create reports that show a list of raw materials and quantities, list of raw materials used in each product, and which employees worked on each product.

APPENDIX B

INSTRUCTIONS

APPENDIX B

INSTRUCTIONS

Pre-Test

The Access pre-test has 10 multiple-choice questions. You will have one attempt to complete it. Please do not look up any information, just do the best you can. It is an assessment to see what you already know and will not have any impact on your grade.

Memletics Styles Questionnaire

This is a 10-question inventory to analyze your learning style preference. It will take about 10-15 minutes to complete it. For each statement, indicate how well it describes you (not at all, partially, or very much). Once you complete this, I'll email your results so you know how you learn best.

Structured online tutorial

Here is a link to a tutorial about creating relational databases. You can visit it as often as you'd like.

On the website: Go through the tutorial in any order you would like. Clicking on the Main Menu button on any page takes you to the table of contents. There are sets of explanations followed by short quizzes to test your knowledge. Nothing you do is recorded--it is simply to help you learn how to create an effective relational database. If you have any questions, just email Judy Paternite (jpaterni@kent.edu)

Problem-Based Learning Activity

For the group activity, you will be assigned to a group with 3-4 classmates. You will work together, through the discussion board, to design a relational database (no data needed). The directions are in the first discussion post.

In discussion forum: Your task is to work together to design an effective relational database based on the following scenario. No data is needed, but you do need to determine what tables are needed, what fields belong in each table, and how the tables are related to each other. You can type in the discussion, and you can attach files if you decide to work up a design in Word, Excel, Access, or PowerPoint. (Scenario is shown below this paragraph in the discussion.)

Post-Test

Create a relational database based on the scenario below. No data is required for this activity. You can use Word, Excel, Access, PowerPoint, or Visio to design the database. Attach your document to this assignment and submit it. (Scenario is shown below this paragraph in the assignment.)

APPENDIX C

TUTORIAL

APPENDIX C

TUTORIAL

Below are screen shots and additional information about the online tutorial:

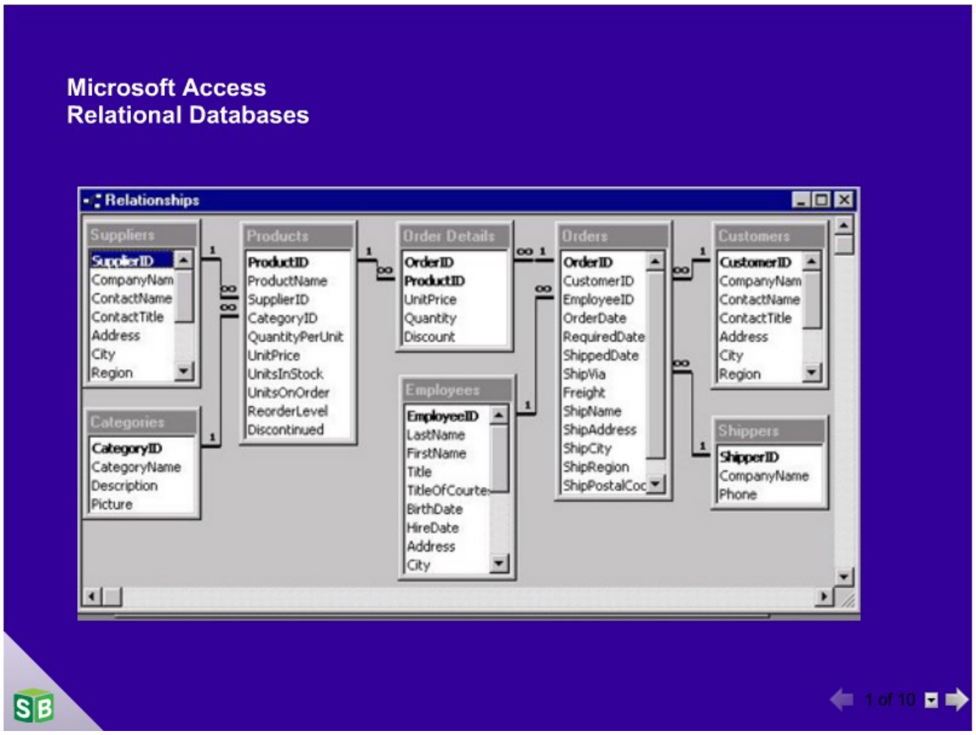


Figure 5: Opening Screen

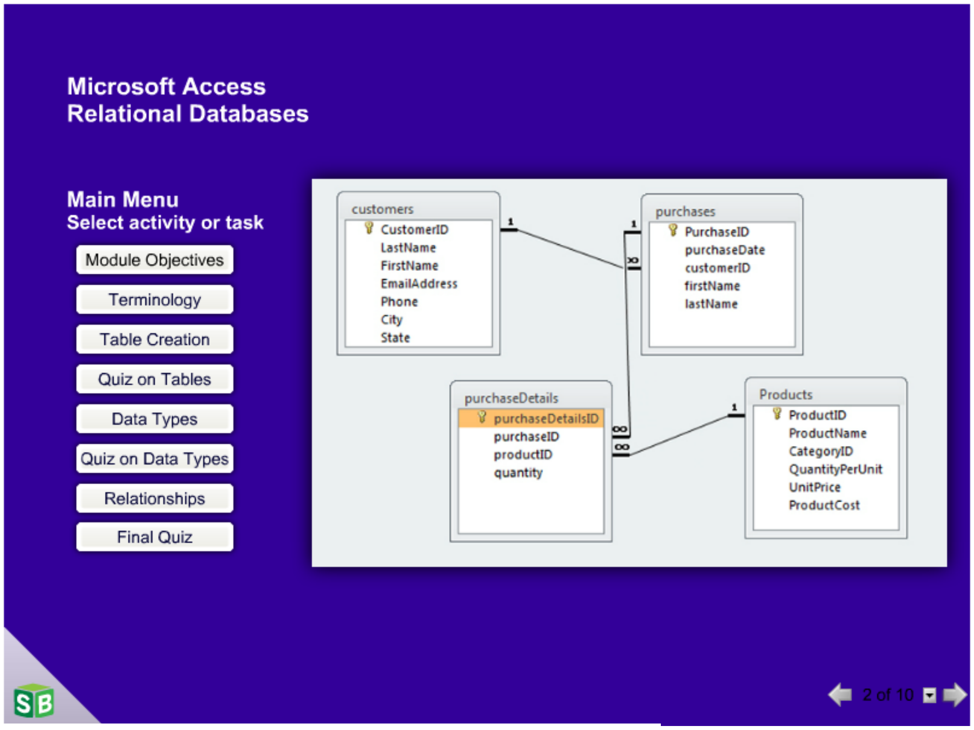


Figure 6: Main Menu

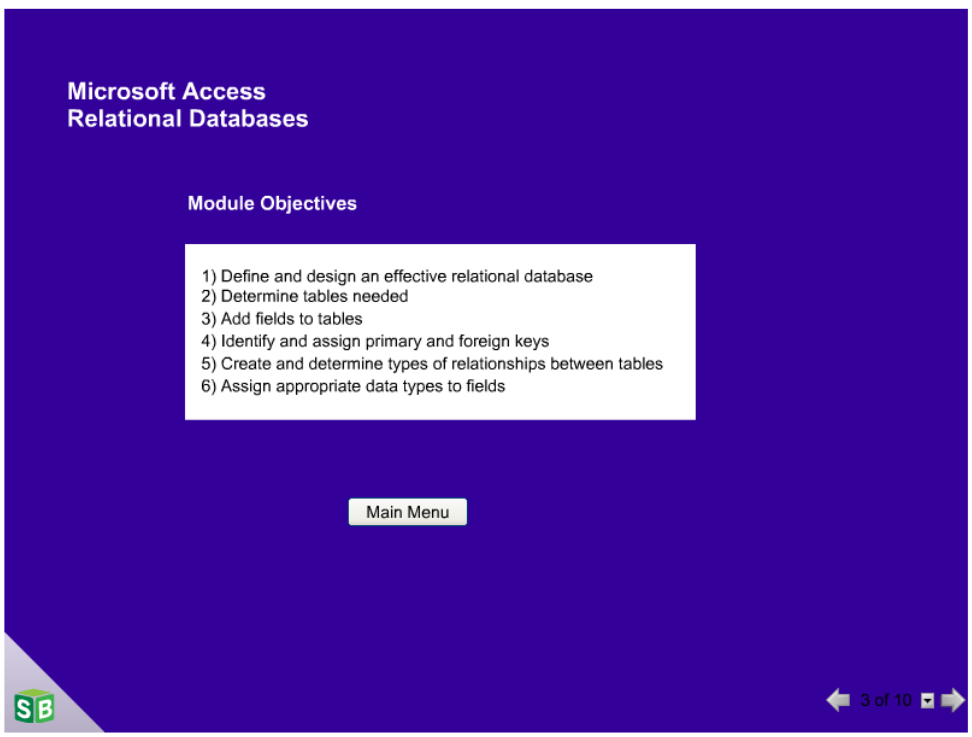


Figure 7: Module Objectives

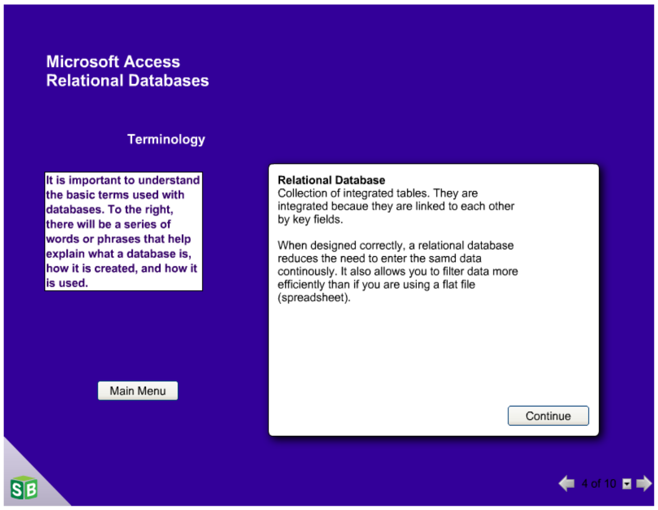


Figure 8: Terminology

Terminology:

Five additional screens are included in this section. Each provides a term and its definition. They are as follows:

Tables
A table is a collection of data about a specific topic such as customers, products, or supplies. Using a separate table for each topic means that you store that data only once. This results in a more efficient database and fewer data-entry errors.

Fields
Each table is composed of a series of fields that define elements of a table. Each field is a fact or attribute about a particular subject.

For example, you might need to store the folowing facts about your customers: company name, adress, city, state, zip, and phone. You would create a separate field for each of these bits of information. Any fact on which you would want to sort or filter data needs to be created as a separate field. If you want to sort by last name, you will have to create separate fields for both first and last names of the customers.

Primary Key
To connect information stored in separate tables (i.e., to connect a customer's contact information with that customer's orders), each table in your database must include a field or set of fields that uniquely identifies each individual record in the table. Such a field or set of fields is called a primary key.

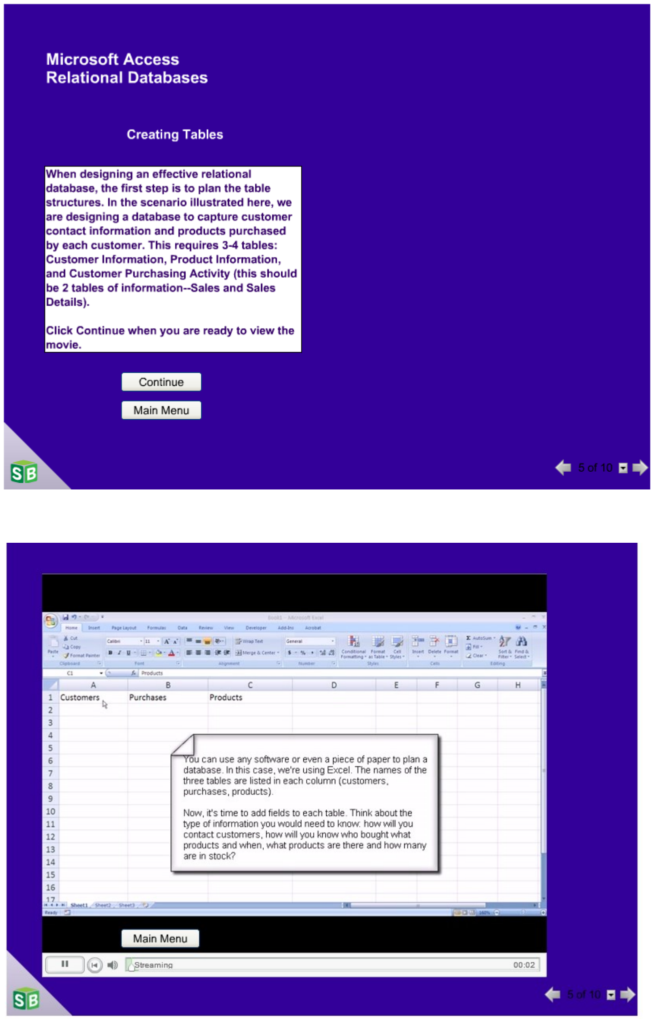
A primary key can be a simple auto increment number (1, 2, 3, etc.) or an alphanumeric text (jd1234). In a table, the primary key cannot be duplicated, so it will only exist once in a table; thereby, it is associated with a single record of information. Ex.: jd1234 is the customerID for John Doe--the 1234 is the last 4 digits of his phone number.

Foreign Key
This key also links information from one table to another; however, it is not the identifying field of a record. Instead, it is a key that is used as a primary key in another table.

For example, in the orders table, you would have a primary key identifying each record (OrderID). Another field would be the customerID that would be used to link the information in the customer table to the orders table. In the orders table, customerID would be a foreign key. In the customer table, customerID would be a primary key.

Redundancy
Tables should be created to reduce redundancy. You don't want to have to key in the same information over and over again, so you would create more tables that link to each other.

For example, if you were keeping track of customers' orders, you would not want to have to type in the product description each time someone purchased that product. So, you'd create a separate table that contained information about the individual products and link that to the orders table.



Camtasia Video

Video that explains and shows creating tables, fields, and relationships between tables. Video has both audio and text captions with controls to pause, fast forward, and rewind.

Figure 9: Tables, Fields and Relationships Video

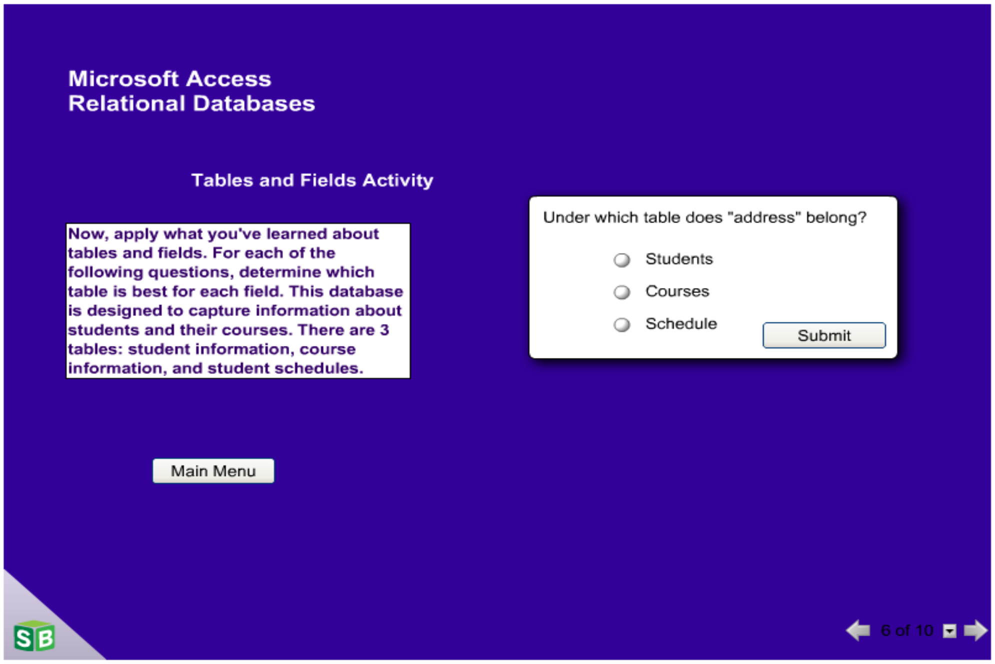


Figure 10: Tables and Fields Quiz

Tables and Fields Quiz

Consists of 5 questions. Feedback is given for correct and incorrect answers. Three attempts for each question are allowed. Results are shown at the end. The other 4 questions with same choices as those shown are:

Under which table does “course description” belong?
Under which table does “semester taken” belong?
Under which table does "studentID" as a primary key belong?
Under which table does "studentID" as a foreign key belong?

APPENDIX D

PRE-TEST QUESTIONS

APPENDIX D

PRE-TEST QUESTIONS

Access Pre-test

True/False
Indicate whether the statement is true or false.

____ 1. With Access, first you save an empty database, then you create the elements that make up the database.

____ 2. You need to save the database when adding or editing data.

____ 3. It is okay to have up to two records with the same value as the primary key.

Multiple Choice
Identify the choice that best completes the statement or answers the question.

____ 4. A ________ is composed of fields and records.

a. query
b. form
c. window
d. table

____ 5. A ______ contains information about a single "entity" in the database--a person, place, event, or thing.

a. query
b. form
c. record
d. table

____ 6. Use the ______ data type for fields that contain words and symbols of up to 255 characters in length.

a. Text
b. Memo
c. Number
d. Date/Time

____ 7. Use the ______ data type for fields that contain numeric data.

a. Decimal
b. Numeric
c. Number
d. Data/Time

____ 8. Use the _______ data type for fields that contain variable length data, such as comments, notes, and reviews.

a. Text
b. Memo
c. Number
d. Date/Time

____ 9. In a database, rows represent_______.

a. records c. fields
b. tables d. queries

____ 10. In a database, columns represent ________.
a. records c. fields
b. tables d. queries

Answer Section

TRUE/FALSE

1.	ANS: T	PTS: 1
2.	ANS: F	PTS: 1
3.	ANS: F	PTS: 1

MULTIPLE CHOICE

4.	ANS: D	PTS: 1
5.	ANS: C	PTS: 1
6.	ANS: A	PTS: 1
7.	ANS: C	PTS: 1
8.	ANS: B	PTS: 1
9.	ANS: A	PTS: 1
10.	ANS: C	PTS: 1

APPENDIX E

RUBRIC

APPENDIX E

RUBRIC

Table 3

Rubric for Evaluating Relational Database Design—15 Points Possible

Points	Tables	Fields
12	4 tables	All relevant fields in correct places
11		Missing 1-2 fields or 1 redundant
10		Missing 3-4 fields or 2 redundant
9		Missing 5-6 fields or 3 redundant
8	3 tables	All relevant fields in correct places
7		Missing 1-2 fields or 1 redundant
6		Missing 3-4 fields or 2 redundant
5		Missing 5-6 fields or 3 redundant
4	2 tables	All relevant fields in correct places
3		Missing 1-2 fields or 1 redundant
2		Missing 3-4 fields or 2 redundant
1		Missing 5-6 fields or 3 redundant

Additional points:

Points	Relationships
3	All correct
2	1 wrong or missing
1	2 wrong or missing

APPENDIX F

LEARNING STYLES INVENTORY

APPENDIX F

LEARNING STYLES INVENTORY

For each item, points were determined as follows:

a. The statement is nothing like me = 0
b. The statement is partially like me = 1
c. The statement is very much like me = 2

10 Items Selected for Study:

1. You have a personal or private interest or hobby that you like to do alone.
5. You are happy in your own company. You like to do some things alone and away from others.
6. You enjoy learning in classroom style surroundings with other people. You enjoy the interaction to help your learning
12. You prefer to study or work alone.
13. You like being a mentor or guide for others.
18. You communicate well with others and often act as a mediator between them.
27. You prefer to talk over problems, issues, or ideas with others, rather than working on them by yourself.
46. You read self-help books, or have been to self-help workshops or done similar work to learn more about yourself.
54. You prefer to work for yourself - or you have thought a lot about it.
62. You are OK with taking the lead and showing others the way ahead.

Multiple Choice

Identify the choice that best completes the statement or answers the question.

____ 1. You have a personal or private interest or hobby that you like to do alone.
a. the statement is nothing like me
b. the statement is partially like me
c. the statement is very much like me

____ 2. You put together itineraries and agendas for travel. You put together detailed lists, such as to-do lists, and you number and prioritize them.
a. the statement is nothing like me
b. the statement is partially like me
c. the statement is very much like me

____ 3. Jingles, themes or parts of songs pop into your head at random.
a. the statement is nothing like me
b. the statement is partially like me
c. the statement is very much like me

____ 4. Maths and sciences were your preferred subjects at school.

a. the statement is nothing like me
b. the statement is partially like me
c. the statement is very much like me

____ 5. You are happy in your own company. You like to do some things alone and away from others.
a. the statement is nothing like me
b. the statement is partially like me
c. the statement is very much like me

____ 6. You enjoy learning in classroom style surroundings with other people. You enjoy the interaction to help your learning.
a. the statement is nothing like me
b. the statement is partially like me
c. the statement is very much like me

____ 7. You like to read everything. Books, newspapers, magazines, menus, signs, the milk carton etc.
a. the statement is nothing like me
b. the statement is partially like me
c. the statement is very much like me

____ 8. You can easily visualize objects, buildings, situations etc from plans or descriptions.
a. the statement is nothing like me
b. the statement is partially like me
c. the statement is very much like me

____ 9. You are goal oriented and know the direction you are going.
a. the statement is nothing like me
b. the statement is partially like me
c. the statement is very much like me

____ 10. You prefer team games and sports such as football/soccer, basketball, netball, volleyball etc.
a. the statement is nothing like me
b. the statement is partially like me
c. the statement is very much like me

____ 11. You navigate well and use maps with ease. You rarely get lost. You have a good sense of direction. You usually know which way North is.
a. the statement is nothing like me
b. the statement is partially like me
c. the statement is very much like me

____ 12. You prefer to study or work alone.
a. the statement is nothing like me
b. the statement is partially like me
c. the statement is very much like me

____ 13. You like being a mentor or guide for others.
a. the statement is nothing like me
b. the statement is partially like me
c. the statement is very much like me

____ 14. You spend time alone to reflect and think about important aspects of your life.
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 15. In regular conversation you frequently use references to other things you have heard or read.
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 16. You enjoy finding relationships between numbers and objects. You like to categorize or group things to help you understand the relationships between them.
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 17. You keep a journal or personal diary to record your thoughts.
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 18. You communicate well with others and often act as a mediator between them.
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 19. You love sport and exercise.
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 20. You like to listen. People like to talk to you because they feel you understand them.
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 21. You like listening to music - in the car, studying, at work (if possible!).
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 22. You can balance a checkbook, and you like to set budgets and other numerical goals.
a. The statement is nothing like me
b. The statement is partially like me

c. The statement is very much like me

____ 23. You have a number of very close friends.
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 24. You use lots of hand gestures or other physical body language when communicating with others.
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 25. English, languages and literature were favorite subjects at school.
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 26. You like making models, or working out jigsaws.
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 27. You prefer to talk over problems, issues, or ideas with others, rather than working on them by yourself.
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 28. Music was your favorite subject at school
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 29. In school you preferred art, technical drawing, geometry.
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 30. You love telling stories, metaphors or anecdotes
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 31. You like identifying logic flaws in other people's words and actions.
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 32. You like using a camera or video camera to capture the world around you.
a. The statement is nothing like me

b. The statement is partially like me
c. The statement is very much like me

____ 33. You use rhythm or rhyme to remember things, eg phone numbers, passwords, other little sayings.
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 34. In school you liked sports, wood or metal working, craft, sculptures, pottery.
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 35. You have a great vocabulary, and like using the right word at the right time
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 36. You like the texture and feel of clothes, furniture and other objects.
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 37. You would prefer to holiday on a deserted island rather than a resort or cruise ship with lots of other people around.
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 38. You like books with lots of diagrams or illustrations.
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 39. You easily express yourself, whether it's verbal or written. You can give clear explanations to others.
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 40. You like playing games with others, such as cards and board games.
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 41. You use specific examples and references to support your points of view.
a. The statement is nothing like me
b. The statement is partially like me

c. The statement is very much like me

____ 42. You pay attention to the sounds of various things. You can tell the difference between instruments, or cars, or aircraft, based on their sound
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 43. You have a good sense of color.
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 44. You like making puns, saying tongue-twisters, making rhymes.
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 45. You like to think out ideas, problems, or issues while doing something physical.
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 46. You read self-help books, or have been to self-help workshops or done similar work to learn more about yourself.
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 47. You can play a musical instrument or you can sing on (or close to) key
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 48. You like crosswords, play scrabble and word games.
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 49. You like logic games and brainteasers. You like chess and other strategy games.
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 50. You like getting out of the house and being with others at parties and other social events.
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 51. You occasionally realize you are tapping in time to music, or you naturally start to hum or whistle a tune. Even after only hearing a tune a few times, you can remember it.
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 52. You solve problems by "thinking aloud" - talking through issues, questions, possible solutions etc.
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 53. You enjoy dancing.
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 54. You prefer to work for yourself - or you have thought a lot about it.
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 55. You don't like the sound of silence. You would prefer to have some background music or other noises over silence.
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 56. You love the theme park rides that involve lots of physical action, or you really hate them because you are very sensitive to the effect the physical forces have on your body.
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 57. You draw well, and find yourself drawing or doodling on a notepad when thinking.
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 58. You easily work with numbers, and can do decent calculations in your head.
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 59. You use diagrams and scribbles to communicate ideas and concepts. You love whiteboards (and color pens).
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 60. You hear small things that others don't.
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 61. You would prefer to physically touch or handle something to understand how it works.
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 62. You are OK with taking the lead and showing others the way ahead.
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 63. You easily absorb information through reading, audiocassettes or lectures. The actual words come back to you easily.
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 64. You like to understand how and why things work. You keep up to date with science and technology.
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 65. You are a tinkerer. You like pulling things apart, and they usually go back together OK. You can easily follow instructions represented in diagrams.
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 66. Music evokes strong emotions and images as you listen to it. Music is prominent in your recall of memories
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 67. You think independently. You know how you think and you make up your own mind. You understand your own strengths and weaknesses.
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

____ 68. You like gardening or working with your hands in the shed out the back.
a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

_____ 69. You like visual arts, painting, sculpture. You like jigsaws and mazes.

a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

_____ 70. You use a specific step-by-step process to work out problems.

a. The statement is nothing like me
b. The statement is partially like me
c. The statement is very much like me

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