Using Community of inquiry to Examine the Effect of Station Rotation Strategy in Elementary Mathematics

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ABSTRACT

USING COMMUNITY OF INQUIRY TO EXAMINE THE EFFECT OF STATION ROTATION STRATEGY IN ELEMENTARY MATHEMATICS

Ahmad Alshahrani, Ph.D.
Northern Illinois University, 2021
Department of Educational Technology, Research and Assessment
Hayley Mayall, Director

Problem-based learning (PBL) has been implemented to encourage students to learn through problem-solving in the Kingdom of Saudi Arabia (KSA). However, this method does not address students’ capability to apply the knowledge learned, and a new learning approach is needed. The current study examined the effects of using a station rotation strategy on students’ achievement, attitude, and educational presence using a sample of 50 male sixth-grade mathematics students in the KSA, using the community of inquiry (CoI) as a framework. The findings demonstrated that there were statistically significant, positive effects of the station rotation strategy on student achievement, student attitude, and student education presence toward learning mathematics.

The results of this study concur with previous studies of the station rotation successes in student curricula. Both student achievement and attitude improved in response to the intervention. The KSA education system can use results from this study to inform use of a station rotation strategy in classrooms, as it creates an effective learning environment for students and allows teachers to increase the individual focus on each student.
NORTHERN ILLINOIS UNIVERSITY
DEKALB, ILLINOIS

MAY 2021

USING COMMUNITY OF INQUIRY TO EXAMINE THE EFFECT OF STATION ROTATION STRATEGY IN ELEMENTARY MATHEMATICS

BY

AHMAD ALSHAHRANI
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A DISSERTATION SUBMITTED TO THE GRADUATE SCHOOL
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE
DOCTOR OF PHILOSOPHY

DEPARTMENT OF EDUCATIONAL TECHNOLOGY, RESEARCH AND ASSESSMENT

Doctoral Director:
Hayley Mayall
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CHAPTER 1
INTRODUCTION TO RESEARCH PROBLEM

In recent years, the quality of education, especially in mathematics, among students in the Kingdom of Saudi Arabia (KSA) has come under scrutiny. According to Alreshidi (2016), students’ performance in mathematics is not as high as expected and drastic measures must be implemented to correct the situation. Similarly, Mansour and Al-Shamrani (2015) argue there is a need to improve students’ ability to learn and develop effective communication and higher order thinking skills in mathematics. Consequently, the Ministry of Education in the KSA has provided additional training courses for teachers and implemented a new curriculum designed to improve students’ achievement in mathematics. Nonetheless, students’ resistance to learning mathematics has had a negative effect on their performance (Mansour & Al-Shamrani, 2015).

Problem-based learning (PBL) is an approach that has been applied in the KSA to improve students’ performance in mathematics (Alreshidi, 2016). A study conducted by Filipenko et al. (2016) found that students encouraged each other to acquire new knowledge through the process of problem solving; however, the authors cautioned that students may be unable to apply the knowledge learned through this strategy. Mansour and Al-Shamrani (2015) reiterated this sentiment, arguing that students not only should acquire knowledge to improve their skills in solving problems but also must understand how to apply the knowledge. Therefore, there is a need for a new learning approach that will change the way students learn. One possibility is the station rotation learning strategy, in which students move through various
locations in the classroom focusing on different information or sources, with at least one of the
stations using technology (Horn & Staker, 2011). Several previous studies have shown that
station rotation can have a positive effect on students’ performance and attitude (Jones, 2004;
Truitt, 2016). The use of this strategy for teaching mathematics has changed the way students
learn by individualizing instruction to meet students’ needs. Each station provides a specific task
based on different learning approaches, which include independent, collaborative, and
technology-based methods. As a result, the station rotation strategy enables mathematics teachers
to create an effective learning environment for the students. The station rotation strategy also
helps teachers reduce group sizes, allowing them to focus more on each student.

Problem Statement

The problems of low achievement and engagement levels in learning mathematics are the
main challenges in the KSA schools (Almaleki, 2010). According to the Trends in International
Mathematics and Science Study (TIMSS, 2019), the mean math achievement score among
fourth-grade students in the KSA between 2008 and 2019 was 410, which is significantly less
than the TIMSS scale average of 500 and ranks as the lowest achievement score among the East
Asian countries. Thus, improving students’ performance on the TIMSS tests is one of the most
important objectives of the new educational vision of the KSA. There are four primary goals to
be achieved by 2030: close the gap between the output of higher education and job market
requirements, develop the education system, improve five Saudi universities to rank among the
top 200 universities worldwide, and help students achieve results that exceed international
education averages (National Planning Commission, 2030).
Although a large body of research (Alafaleq & Fan 2014; Albalawi, 2013.; Alghamdi, 2017; Al-Madani, 2015) has studied the impact of using various approaches, such as PBL, to improve students’ performance in and attitude toward mathematics in K–12 in the KSA (Alreshidi, 2016) and a few studies have investigated the effects of using blended learning approaches (Alasraj & Alharbi, 2014; Al-Madani, 2015; Khader, 2016), the impact of the station rotation blended learning strategy on students’ low achievement and negative impressions toward learning mathematics has not been investigated. Therefore, this study explores the efficacy of the station rotation learning strategy, a blended learning practice, for improving sixth-grade students’ performance, attitude, and education presence in mathematics in the KSA.

Theoretical Framework

The community of inquiry (CoI) framework, developed by Garrison, Anderson, and Archer (2001), underlines teaching, social, and cognitive presence as essential elements of the learning environment (see Figure 1) and presents categories and indicators to define each of the presences (Garrison et al., 2001; see Figure 2). The CoI framework explains how learning can be enhanced through an educational experience that lies at the intersection of teaching, social, and cognitive presence (Garrison et al., 2001). Through successful marshalling of these three elements, students can maintain a conducive online learning environment (Garrison et al., 2001).

Garrison (2011) defined CoI framework as a “group of individuals who collaboratively engage in purposeful critical discourse and reflection to construct personal meaning and confirm mutual understanding” (p. 2). The CoI framework has provided a useful tool and approach to studying online learning (Garrison et al., 1999). In addition, Garrison et al. (1999) emphasized
that CoI framework creates deep and meaningful collaborative and constructivist learning activities through the interconnection of teaching, cognitive, and social presence.

The three elements of the CoI framework are defined as follows: teaching presence is “the design, facilitation, and direction of cognitive and social processes for the purpose of realizing personally meaningful and educationally worthwhile learning outcomes” (Anderson et al, 2001; p. 5); social presence is “the ability of participants to identify with the community (e.g., course of study), communicate purposefully in a trusting environment, and develop interpersonal relationships by way of protecting their individual personalities” (Garrison, 2009b; p. 352); and cognitive presence is “the extent to which learners are able to construct and confirm meaning through sustained reflection and discourse in a critical community of inquiry” (Garrison et al., 2001, p. 11). Each of these presences has specific categories and indicators (see Table 1). Figures 1 and 2 show the conceptual to observational levels of the CoI framework.

Figure 1: Community of inquiry (CoI; adapted from Garrison, Anderson & Archer, 1999, p.88).
Figure 2. Inquiry process model (Adapted from Garrison, Anderson & Archer, 1999, p.63).

Table 1
Community of Inquiry Framework (CoI)

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<td>Social Presence</td>
<td>Personal/affective</td>
<td>Self-projecting/expressing emotions</td>
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<td></td>
<td>Open communication</td>
<td>Learning climate/risk-free expression</td>
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<td></td>
<td>Group cohesion</td>
<td>Group identity/collaboration</td>
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<tr>
<td>Cognitive Presence</td>
<td>Triggering</td>
<td>Sense of puzzlement</td>
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<td>Exploration</td>
<td>Information exchange</td>
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<td></td>
<td>Integration</td>
<td>Connecting ideas</td>
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<td></td>
<td>Resolution</td>
<td>Applying new ideas</td>
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(Garrison, 2011, p. 25)
Blended Learning and Community of Inquiry

The CoI framework has become an important approach for designing blended learning educational environments (Chang-Tik, 2018; Harrell & Wendt, 2019; Law et al., 2019; Makri et al., 2014; Pollard, 2015; Szeto & Cheng, 2016). Research carried out by different scholars (Mirabolghasemi et al., 2018; Shea et al., 2005; Wang & Chen, 2008) has identified a positive relationship between the CoI framework presences and student achievement and satisfaction toward learning in blended learning environments. According to research completed by Daspit and D’Souza (2012), Makri et al. (2014), and Russo and Benson (2005), the CoI framework helps to enhance the communication levels of individuals through group collaboration and cohesion in a blended learning environment, and this communication can help students to value education, learn from each other, and freely express their views.

Teaching presence is one of the core elements of the learning process that can connect a CoI framework learning community and help in designing an effective learning environment (Anderson et al., 2001; Garrison & Cleveland-Innes, 2005). Research has identified a positive relationship between CoI teaching presence and other indicators such as student perceptions of learning, motivation, and satisfaction (Akyol et al., 2009; Baker, 2010; Russo & Benson, 2005; Shea et al., 2005; Shea et al., 2003). Research by Law et al. (2019) indicated that teaching presence is an essential component of blended learning as it has a direct positive impact on both cognitive and social presence, with an indirect positive impact on learning performance. When teaching presence is emphasized in blended learning environments, such as through computer-mediated communication, learners are able to effectively connect with their course content because they are guided by their teachers regardless of technology use (Gurley, 2018; Law et al.,
Gurley (2018) further suggested that how educators teach will inevitably impact the quality of instruction provided in blended and online courses. Thus, the teaching presence is an integral component in achieving positive learning outcomes. Furthermore, a study conducted by Harrell (2017) suggested that teaching presence provides the needed leadership for the development of community and pursuit of inquiry. Harrell (2017) also indicated that teaching presence is an indicator of online and blended learning instructional quality as it embodies cognitive and social presences, thus leading to a fruitful critical inquiry in blended learning environments.

The second CoI framework element—social presence—describes the ability of individuals to identify with the course and community, the relationships and connections between instructors and the students, and the factors that motivate individuals to communicate and project their personalities (Akyol et al., 2009). There are three indicators of social presence: effective expression, when class members share their expressions of emotion, beliefs, and values; open communication, when communication exchanges between the class members are based on being reciprocal and respectful; and group cohesion, when class members cooperate in common intellectual tasks and activities (Anderson et al., 2001).

Research by Maddrell et al. (2017) indicated that the CoI framework fosters educational experiences and highlights that social presence is a construct that helps in examining the link between peer interactions and student learning. Similarly, Hostetter (2013) indicated that social presence significantly impacts student achievement as it influences the amount of salience a student has in interacting with others. Lim and Richardson (2016), on the other hand, suggested that social and facilitating roles are emphasized in an online environment because of lack of physical interaction and presence. Similarly, social presence is positively correlated with
students’ satisfaction and retention (Mirabolghasemi et al., 2018; Richardson et al., 2016). Furthermore, research finds a relationship between a positive perception of using social networking for educational purposes and social presence.

The third CoI framework element—cognitive presence—is characterized by triggering events, exploration, integration, and resolution on the part of the student (Anderson et al., 2001). Cognitive presence provides numerous ways of facing challenging problems and questions through individual participation, proposing new ideas and possible solutions (Beckmann & Weber, 2016). Meanwhile, research by Akyol et al. (2009), Maddrell (2017), and Hostetter (2013) has shown that the more students relate or connect to their instructors, the more likely they are to handle challenging problems due to good guidance, which helps develop their understanding. Related literature also indicates that cognitive presence has a positive impact on students’ critical thinking and on their motivation to participate in blended learning courses (Akyol et al., 2009; Breivik, 2016; Kovanović et al., 2016; Olesova et al., 2016). Similarly, there is evidence that the structure and moderation of online discussions based on cognitive presence can help diagnose strengths and weaknesses of discussion settings and enhance learning activity in online environments (Beckmann & Weber, 2016; Shea & Bidjerano, 2009; Wang & Chen, 2008).

Through cognitive presence, students tend to experience an element of puzzlement that fosters the desire to learn more, thereby encouraging information exchange beyond connecting ideas and applying them as appropriate (Akyol & Garrison, 2011; Beckmann & Weber, 2016; Darabi et al., 2011; Shea & Bidjerano, 2009). Breivik (2016) shared similar sentiments, suggesting that young learners, especially adolescents experiencing changes in their cognitive development and social relationships, can make significant improvements in meeting their
learning goals if they are supported by their teachers to participate in group sessions where they
developed through peer observation and internalize actions through perceptive cognition.
Furthermore, Kovanović et al. (2016), observed that the cognitive learning cycle provides a great
potential for young learners to acquire appropriate content in their learning. Olesova et al. (2016)
established that cognitive presence has a positive impact on students’ critical thinking and their
motivation to participate in online discussions. Additional information about the CoI framework
and a station rotation strategy construct is presented in Chapter 2.

Purpose of the Study

The purpose of this study was to examine the effect of using a station rotation strategy on
students’ achievement, attitude, and educational presence in a sixth-grade mathematics class in
the KSA. To make this possible, I used CoI as a framework to design the station rotation learning
mathematics lessons. The constructs of the CoI framework were useful for evaluating the results
of using station rotation as well as comparing this approach to traditional face-to-face instruction.

Research Questions and Hypotheses

This study examined the effect of using station rotation on students’ achievement in and
attitude toward mathematics. For this purpose, the following research questions and hypotheses
were investigated:

1. Do sixth-grade Saudi Arabian students in a station rotation mathematics course show
   higher mathematics achievement than students in a traditional face-to-face instruction
   mathematics course?
2. Do sixth-grade Saudi Arabian students in a station rotation mathematics course show a more positive attitude toward learning mathematics than students in a traditional face-to-face instruction mathematics course?

3. Do sixth-grade Saudi Arabian students in a station rotation mathematics course show more positive perceptions of educational presence (perceptions of teaching presence, social presence, and cognitive presence) than students in a traditional face-to-face instruction mathematics course?

The following research hypotheses guided this study:

H1: The mean posttest achievement scores of students in a station rotation mathematics course will be higher than the mean scores of students receiving traditional face-to-face instruction.

H2: The mean posttest scores for the intervention group will be higher than the mean posttest scores for the comparison group in the TIMSS constructs Students Like Learning Mathematics and Students Confident in Mathematics.

H3: The mean posttest “perceptions of educational presence” scores of students in a station rotation mathematics course will be higher than the mean scores of students receiving traditional face-to-face instruction.

Significance of the Study

Studying the implementation of the station rotation strategy in a sixth-grade classroom is significant for many reasons. First, this study will help educators understand what the station rotation strategy can look like within a classroom. Another significant aspect of this study is that it gives administrators and educators an opportunity to explore the effect station rotation has on
enhancing students’ achievement results and builds a foundation for future studies using the station rotation strategy for teaching mathematics.

The recommendations from this study could help other researchers in the educational technology field conduct further studies on different grades or develop different research designs to investigate the effectiveness of station rotation as a teaching approach. Finally, the findings of this study could help the Ministry of Education in the KSA make decisions about implementing the station rotation strategy in the K–12 curricula and develop a training program to help teachers use it effectively.

Definition of Terms

**Attitude**: Based on Aiken’s (2000) definition, attitude is “a learned predisposition to respond positively or negatively to a specific object, situation, institution, or person” (p. 248).


**Cognitive Presence**: This term indicates “the extent to which learners are able to construct and confirm meaning through sustained reflection and discourse in a critical community of inquiry” (Garrison et al., 2001, p. 11)

**Educational Presence**: Educational presence tends to involve numerous aspects, such as operational perceptions, teaching presence, social presence, and cognitive presence (Anderson et al., 2001).

**Engagement**: According to Skinner et al. (2009), engagement is “the quality of a student’s sense of connection or involvement with the endeavor of schooling and hence with the people, activities, goals, values, and place that compose it” (p. 494).
**Self-Confidence:** Self-confidence is a student’s belief in their capacity to perform a particular task (Bandura, 1977).

**Station Rotation Strategy:** The station rotation strategy describes an approach in which students rotate through stations on specific timetables with specific directions and in which at least one of the stations is an online learning station (Horn & Staker, 2011).

**Student Achievement:** Khader (2016) has defined achievement as “the result of what was learned by the students directly after the end of the educational material” (p. 112). In the present study, achievement was operationally defined as the students’ scores on three quizzes.

**Social Presence:** This term indicates “the ability of participants to identify with the community (e.g., course of study), communicate purposefully in a trusting environment, and develop interpersonal relationships by way of protecting their individual personalities” (Garrison, 2009b; p. 352).

**Teaching Presence:** This term indicates “the design, facilitation, and direction of cognitive and social processes for the purpose of realizing personally meaningful and educationally worthwhile learning outcomes” (Anderson et al., 2001; p. 5).

**Traditional Face-to-Face Instruction:** This term describes an instructional method in which an instructor teaches both learning materials and course content to a group of students (Horn & Staker, 2011). The instructor and learners interact live since learning and teaching takes place in a common place and time.

**Chapter Summary**

In summary, the quality of and performance in education in the KSA, particularly mathematics, has undergone significant scrutiny. Consequently, the Ministry of Education has
identified a need to improve the KSA students’ ability to learn and develop effective communication and thinking skills in the field of mathematics. The institution has applied problem-based learning to curb the situation; however, that approach has not been effective for improving international test scores. A process of CoI framework has been introduced to the students to form constructivist and collaborative learning activities through three significant interconnections: cognitive, teaching, and social presence. Additionally, because CoI framework has a cohesive relationship with station rotation, the Ministry plans to use the combination to provide students with numerous ways of learning and understanding mathematics. In the long run, the KSA’s students could experience significant improvement as a result of this strategy.
CHAPTER 2
LITERATURE REVIEW

Research on blended learning primarily focuses on its impact on higher education, leaving a gap in the literature regarding its effects on lower education levels, such as K–12 (Chaney, 2017; Zawacki-Richter & Latchem, 2018). Therefore, there is a need for scholars to study the effects of blended learning on K–12 mathematics students’ achievement. This study aims to examine the effect of using a station rotation strategy to improve sixth-grade students’ achievement, attitude, and educational experience in learning mathematics.

This literature review will focus on station rotation blended learning. This strategy is the foundation of this research study; hence, a review of the related literature will provide context and will identify gaps in recent research. The literature review will also highlight the advantages of blending learning and its effect on students’ attitudes towards learning and their overall academic achievement. The literature review will examine the CoI framework and its integration in creating blended learning and a station rotation learning environment. The literature review was conducted using databases, such as Google Scholar and ProQuest, and keywords used to search the databases include “the community of inquiry,” “blended learning impact,” and “mathematics.”
Technology in Blended Learning

In the modern era, technological advancements have bridged the communication gap among nations. These technological advancements penetrated the educational world in the 1980. Before the prevalence of computer technology in education, teachers used resources such as tape recorders, televisions, and radios to deliver a lesson (Cauthen, 2010). Prior to the integration of digital tools into education, information primarily came from the instructors through lectures in a stagnant form of teaching. Students were taught the limited information that the instructor had without knowing if it was correct or not (Khan, 2012). Hence, learning was limited to the boundaries of schooling as well as to teachers’ knowledge (Watson, 2008). After the introduction of the printing press, books were printed in large quantities (Harasim, 2017). Thus, students were taught not only the information that the teacher had but also the information gathered through evidence by experts (Khan, 2012). Nonetheless, education remained teacher centered. With technological advancements, the mode of teaching transformed. The concept of blended learning that brought digitalization to education started in 1983. Since then, the technological changes in educational systems, together with students’ advanced approach towards adopting 21st-century skills for learning purposes, have led teachers to adopt new pedagogies for teaching. The use of technological resources such as the World Wide Web, computers, netbooks, and cell phones has become a significant part of education. Blackboards (also known as chalkboards); whiteboards and, dry erase boards have now been replaced by smart boards, projectors, and scanners (Cauthen, 2010). Technological changes have transformed teacher-oriented classrooms to student-oriented classrooms.
In digital classrooms, teachers typically provide facilitation, guidance, and support of students’ learning process versus spoon feeding them every bit of information. This shift has promoted students’ engagement and active participation in their learning process. For example, in the United States, many schools have incorporated blended learning into their educational practice, which has increased the students’ motivation (Peterson, 2016). Moreover, a study by Sajid et al. (2016) indicated that blended learning improves student satisfaction. Digitalization in education has made the learning process individualized, interactive, and easy to practice. This is because students are not bound by time or place restrictions for their learning. Therefore, learning can take place according to students’ interest and convenience (Horn & Staker, 2011). The use of technology in education has given teachers the ability to use various tools according to students’ mode of learning. Such differentiated environments in the classroom enable the overall growth and development of a student (Kleber, 2015). Technological resources provide additional information and establish social connections in an individualized setting that promotes their learning (Kivunja, 2015). Web-based resource applications such as Khan Academy, teacher blogs, and educational videos provide materials that are easy to comprehend and remember, thereby increasing learning outcomes and overall student performance (Burke et al., 2009).

The integration of technology into education is helpful not only for the students but also for the teachers. Through digital resources, teachers can enhance their knowledge and learn to adopt innovative modes of teaching. The internet contains a wealth of information that is easily accessible and available. Thus, learning remains a continuous process that is not bound by the walls of the classroom, allowing teachers to play a central role in students’ learning. Bergman and Sams (2012) used technology to “flip” their classrooms. They intended to replace teacher-
centered classrooms with student-centered classrooms, thus switching the role of teachers from disseminator to facilitator and motivator.

Blended Learning Definition

Blended learning is defined as an education strategy that combines face-to-face activities and online instruction (Horn & Staker, 2011; McCollum, 2019). Blended learning has now emerged as a trend in education, and learning institutions are moving towards utilizing information communication technologies in academics. Blended learning provides more opportunities to students and instructors compared to the traditional mode of learning. McCollum (2019) highlighted that blended learning is efficient in enhancing students’ productivity by allowing them to work at their own pace. Students have control of the study material, time, and pace of learning, and that control leads to better outcomes (Hubackova & Semradova, 2016). Harrison (2016) noted that there has been a growing trend in using videos and visual images in online discussions, which helps to improve communication between students and instructors. There is a significant amount of convenience and flexibility with blended learning, and it is helping students and instructors to achieve their educational requirements and objectives (Ossiannilsson, 2018). There are a variety of ways through which blending learning can be integrated into educational settings.

Blended Learning Rotation Models

Recent research by Smith and Hill (2019) indicates that blended learning has been an education practice since the 1990s and its popularity has been increasing, especially since it was
adopted in higher education. Institutions of learning have changed their pedagogical models to accommodate the new aspects of blended learning, and more transformation is likely as it is becoming widely adopted (Roux, 2018). Blended learning rotation models take various forms in educational settings, including station rotation, computer lab rotation, and individual rotation (Horn & Staker, 2011; Christensen et al., 2013).

**Station Rotation**

In station rotation, students rotate through stations on specific timetables and follow directions for learning activities; at least one of the stations is an online learning station (Staker & Horn, 2011). Station rotation is one of the most popular blended learning rotation strategies in elementary schools (Kazakoff et al., 2018). One of the main objectives of the station rotation strategy is to combine the advantages of face-to-face and online learning instruction, which can benefit students in many ways. Studies by Hesse (2017) and Kleber (2015) showed that the availability of different resources, including online learning materials, is significant for improving students’ performance. Additionally, station rotation learning environments allow students to perform research at their own pace and achieve their learning objectives effectively’ allowing teachers to provide more support to students who need it (Kazakoff et al., 2018). Moreover, integrating technology into a station rotation learning environment can motivate and promote a high level of self-efficacy in students (Maltez, 2008) and enable them to access the resources and the concepts on which they need more practice, which facilitates understanding (Hinkhouse, 2013). Several studies (Jones, 2004; Kazakoff et al., 2018; Truitt, 2016) have indicated that the station rotation strategy has positive effects on learning outcomes. Truitt’s (2016) findings through observation and student surveys show a relationship between students’
performance and station-based presentation of the content. Acree et al. (2017) outlined that the rotation model offers the students the chance to move through different stations, and through that process, they are able to establish which type of learning is the best for them.

**Computer Lab Rotation**

In the computer lab rotation, the student rotates to a computer lab for the online learning station to continue with a course or subject. Essentially, students attending lab rotations mostly begin with physical face-to-face interaction in a normal classroom setup before rotating to a computer or learning lab center. Lab rotation provides a suitable environment for personalized learning founded on the use of online educational content at the convenience of the learner because it involves technological enhancement lacking in the usual teacher-led classroom setup (Powell et al., 2015).

**Individual Rotation**

Individual rotation is the last of the rotational models. In this strategy, learners are assigned individualized playlists and do not have to rotate to each of the available stations because a computer-based algorithm or the teacher sets the individual student schedules (Staker & Horn, 2012). Individual rotation is a student-centered model that blends face-to-face instruction as a means of personalizing and accelerating the learning process. Thus, while students can navigate their educational expectations at their own pace, the student-to-student interactions serve to re-emphasize the learning goals and optimize positive outcomes.
Effects of Blended Learning

Blended learning strategies play a significant role in connecting digital learning with traditional modes by enhancing technology use in classes and improving the students’ performance (Al-Rimawi, 2014; Banditvilai, 2016; Hesse, 2017; Inal & Korkmaz, 2019; Maccoun, 2016; Mayisela, 2012; McCarthy, 2010; Poon, 2013; Setyaningrum, 2018). Studies by Hesse (2017) and Kleber (2015) revealed that availability of different learning resources that are accessible digitally or physically, such as online learning materials and books, can significantly improve student performance. Similarly, studies by Foon and Fah (2011) and Peterson (2016) demonstrated that the blended learning strategy is more effective in areas concerning academic achievement than traditional methods are.

Advantages of Blended Learning

The deliberate combination of teaching interventions has had an impact on learning, and evidence suggests that there has been an improvement in attendance, attainment of learning, and retention by students (Bowyer & Chambers, 2017). The different types of blended learning ensure that students will remain engaged, and this engagement will inspire them to become proactive in the learning process. According to Nakayama et al. (2016), blended learning ensures that learners can access additional learning materials and get feedback, mentoring, and observance from instructors, all of which will lead to improved knowledge. Therefore, the goal of education will be achieved, and all stakeholders will benefit.

Blended learning is flexible, efficient, and effective. Previous studies by Tan and Hew (2016) have indicated that blended learning allows the students and instructors to focus on
meaningful activities, which is critical in enhancing educational outcomes in learning institutions. Simple activities will be available online, and complex subjects will be taught in classrooms. According to a report by Hockly (2018), interaction, learner and instructor training, and constant evaluation are making blended learning more thoughtful, as higher levels of satisfaction are reported when this technique is used. Blended learning ensures that the instructors plan their activities, and the efficiency and flexibility of this method help to improve the learning experiences of students.

Cost effectiveness also makes blended learning a preferred method of teaching and sharing information. Szadziewska and Kujawski (2017) indicated that the cost of providing education by learning institutions is increasing, and blended learning offers an option for saving resources. Providing education online is easier and cheaper. Traditional learning methods are associated with travel costs, which can hinder individuals’ learning. Kristanto et al. (2017) showed that web-based approaches to teaching ensure students can learn outside the learning environment, and blended learning offers the ability to reduce the cost, effort, and time of offering education. Saving resources will ensure that learning institutions focus on ways of improving the learning experiences, and education will be more accessible to the people.

Blended learning makes education personalized. Boelens et al. (2017) recommended conducting staged procedures and planning to help in realizing the benefits of blended learning, which include easing students' learning process, helping develop a conducive learning climate, and accelerating interactions. Therefore, it would be ideal for students who have learning difficulties because the instructors would ensure an effective transition between the classroom and virtual learning. Chen and Yao (2016) indicated that learner satisfaction affects critical thinking, active learning, communication, and understanding of taught concepts. In blended
learning, there will be improved learner satisfaction, learning will be personalized, and that will be critical in influencing the outcomes of education.

Effects of Blended Learning on Students’ Achievement

Blended learning strategies play a significant role in connecting digital learning with traditional modes by enhancing technology use in classes and improving the students’ performance (Al-Rimawi, 2014; Banditvilai, 2016; Hesse, 2017; Inal, & Korkmaz, 2019; Maccoun, 2016; Mayisela, 2012; McCarthy, 2010; Poon, 2013; Setyaningrum, 2018). Studies by Hesse (2017) and Kleber (2015) have revealed that the availability of different learning resources digitally or physically, such as online learning materials and books, can significantly improve student performance. Similarly, studies by Foon and Fah (2011) and Peterson (2016) showed that the blended learning strategy is more effective in areas concerning academic achievement than traditional methods are. Research on blended learning primarily focuses on its impact on higher education, leaving a gap in the literature regarding its effects on lower education levels, such as K–12 (Chaney, 2017; Zawacki-Richter & Latchem, 2018).

Studies have indicated mixed results regarding student achievement in blended learning environments (Akkoyunlu & Yilmaz-Soylu, 2008; Gambari et al., 2017; Hubackova & Semradova, 2016; McCollum, 2019; Ossiannilsson, 2018). For example, Chaney (2017) established that statistically blended learning environments have no significant relationship with mathematics scores. Chaney (2017) further found no relationship between blended learning and traditional learning on students’ reading scores, although a weak relationship existed between higher reading scores and students’ participation in a fully online program. In contrast, several
studies (Cheung et al., 2016; Poon, 2013; Setyaningrum, 2018) have shown the benefits of blended learning on students’ achievement and have found that blended learning improves students’ performance, especially in technical subjects like mathematics. Blended action research includes two primary approaches, a face-to-face unit and a blended unit. Waynick (2015) revealed that most school administrators recognized and appreciated the significance of blended learning strategies in improving learning outcomes for mathematics in the K–12 setting. Waynick (2015) established that there was a significant rise in learning growth and a positive attitude shift regarding online mathematics learning. Furthermore, the data showed that students’ growth nearly tripled after a blended unit compared to a traditional unit. Waynick (2015) concluded that blended learning moved the students through the material at a faster pace with similar or better comprehension.

Keengwe and Agamba (2015) agreed that the application of blended learning improves the students’ rate of content absorption and understanding. Additionally, a previous study by Korkmaz and Karakus (2009) on the impact of a blended learning model on student attitudes and thinking dispositions indicated that the blended learning model contributed more to students’ critical dispositions and improved their attitudes toward learning compared to a traditional classroom. Khader (2016) conducted an experimental design involving one group that studied a subject using traditional learning experiences and an experimental group that used blended learning. The results revealed a statistically significant difference in post-achievement test scores in favor of the experimental group (Khader, 2016; Utami, 2018). Alternatively, Prescott et al. (2018) found that a blended learning approach was essential in improving literacy outcomes for a diverse cross-section of students, especially during the initial stages of learning in the early grades.
One of the reasons a blended learning strategy contributes to positive outcomes is that students engage more easily when technology is integrated in instructional settings (Al-Rimawi, 2014; Khader, 2016; Lee, 2014; Maccoun, 2016). The high level of interoperability between educational technology and blended models of learning ensures that students are able to easily access learning materials and their instructors remotely, thereby promoting the continuation of learning (Lin & Wang, 2012; Mansour & Al-Shamrani, 2015; Tucker, 2012; Wang et al., 2016). Blended learning gives students control over the learning process and helps them to determine what they need and how to communicate, collaborate, and solve problems in groups, pairs, and individually (Lai & Hwang, 2016; Lin & Tsai, 2016; Sun et al., 2017; Zhu & Yates, 2016). In addition, blended learning enables instructors to design various learning activities that can be tailored to address numerous learning styles (Boelens et al., 2018; Bryant, 2017; McCollum, 2019; Okaz, 2015).

Effects of Blended Learning on Students’ Attitudes

As a result of technological, scientific, and information advancements, blended learning for teaching has changed the way students learn (Huda et al., 2019; Lin et al., 2016; Ndlovu & Mostert, 2018; Ojaleye & Awofala, 2018; Tucker, 2012; Umoh & Akpan, 2014; Zaini & Ahmad, 2010). Recent studies using blended learning have investigated several important variables regarding students’ attitudes, including enjoyment and self-confidence (Alseweed, 2013; Birbal et al., 2018; Kavadella et al., 2012; Yapici & Akbayin, 2012). Studies examining the correlation between students’ enjoyment and their academic achievement show mixed results. Edwards and Rule (2013) explored the difference between middle school students’ attitudes in online and face-to-face learning environments. The results indicate no significant difference in enjoyment of
mathematics between the two approaches. This finding agrees with a study conducted by Cody (2013) that found no significant differences in the students’ levels of enjoyment, understanding, or motivation.

In contrast, numerous studies indicate a relationship between student attitude and students’ academic achievement. For example, Balentyne and Varga (2017) and Hesse (2017) identified a significant positive relationship between students’ attitudes and blended courses when compared to traditional learning strategies. Other studies (Delialioglu, 2012; Hesse, 2017; Lin, 2018; Manwaring, 2017; Mulqueeny et al, 2015; Northey et al., 2018) have investigated the correlation between students’ achievements and their attitudes in a self-paced blended mathematics course and found that enjoyment of blended learning environments positively correlates with achievement. Consequently, using the blended learning strategy improves students’ attitude toward learning (AlAbdulkarim & Albarrak, 2015; Ja'ashan, 2015; Marshall-Stuart, 2018; Pool et al., 2017; Waynick, 2015).

Engagement is one of the attitudinal factors that influences students’ academic achievement (Akpan & Umobong, 2013; Halm, 2015; Jafri, 2017; Reyes et al., 2012). Skinner et al. (2008) have defined engagement as: “the quality of a student’s sense of connection or involvement with the endeavor of schooling and hence with the people, activities, goals, values, and place that compose it”. Studies have shown a significant correlation between students’ engagement and their academic performance (Gunuc, 2014; Karabiyik, 2019; Lee, 2014; Lei et al., 2018;). For instance, Kim et al. (2014) and Lee (2014) identified a significant positive relationship between students’ engagement and students’ performance, while McGeown et al. (2015) found a significant correlation between engagement in learning to read and improvement of students’ word reading skills. Additionally, Alasraj and Alharbi (2014), Ainley and Ainley,
(2011), and Pitsi et al. (2015) have noted that providing learning opportunities can increase students’ engagement in learning. Previous studies, like Dringus and Seagull (2013), Kharb and Samanta (2016), Muhtar et al. (2017) and Firdaus et al. (2020), have found that student engagement can be enhanced through incorporation of the blended learning approach to teaching. For example, Tempelaar et al. (2012) investigated students’ mathematics performance in a course that blended online and face-to-face learning. The results showed a significant positive effect on students’ performance in blended mathematics courses.

Self-confidence is another attitudinal factor imperative for students’ academic success because those with higher academic achievement tend to feel more confident (Chesser-Smyth & Long, 2013; Kukulu et al., 2013; Laranang & Bondoc, 2020; Lehmann et al., 2016). Researchers such as Chesser and Long (2013) and Nurhayati et al. (2017) have found a significant positive relationship between students’ self-confidence and students’ achievement. Additionally, Nurhayati et al. (2017) argued that a collaborative learning strategy like blended learning can improve students’ self-confidence. Teaching through blended learning improves students’ confidence by allowing them to share their ideas and knowledge with peers during teacher-led small group instruction and collaborative activities among students (Headden, 2013; Higgins & Gomez, 2014; Lehmann et al., 2016; Saltan, 2017). Several additional studies have found that teaching through blended learning positively correlates with students’ self-confidence (Lehmann et al., 2016; Nakayama et al., 2016; Uz & Uzun, 2018; Zhang & Han, 2012). For example, Zhang and Han (2012) investigated students’ attitudes and satisfaction toward blended learning in teaching and learning through the web-based college English teaching platforms. They found that blended learning can increase students’ language skills, develop students’ self-confidence, and improve self-learning in learning English. Similarly, Hesse (2017) identified that through
blended learning, students can develop self-paced and self-directed skills to determine their own learning needs and control their learning process. Previous studies (Lin, 2018; Marshall-Stuart, 2018; Tempelaar et al., 2012; Zhang & Han, 2012) have shown that blended learning environments provide better learning since they include both traditional and computer-based teaching, help students to perform better, and increase enjoyment and self-confidence in learning.

Community of Inquiry (CoI) Framework

Several theories have been used to investigate the effectiveness of blended learning strategies in education research (Adekola et al., 2017; Rajkoomar & Raju, 2016; Ramakrisnan et al., 2012). One of the theories is the CoI framework (Harrell & Wendt, 2019; Law et al., 2019; Pool et al., 2017; Wicks et al., 2015), which encompasses three essential components of educational presence: teaching, social, and cognitive presence. Richardson et al. (2017) found the CoI framework emphasizes that an online educational experience for learners, needs to facilitate linkage between teaching, social, and cognitive presences. Sutton (2018) points out that the CoI framework provides a rational framework for understanding how the three presences combine to improving the learning process.

Research suggests that applying the CoI framework in a blended learning classroom enhances learning opportunities for students, improves interactions between instructor and students to extend discussions, and fosters instructor feedback and support during the learning process (Cooper & Scriven, 2017; Kucuk & Sahin, 2013; Law et al., 2019; Szeto & Cheng, 2016; Weidlich & Bastiaens, 2019). Research has also shown a positive relationship between the CoI teaching, social, and cognitive presences and student achievement and satisfaction toward
learning in blended learning environments (Akyol & Garrison, 2011; Akyol et al., 2009; Garrison et al., 2010). According to Beckmann and Weber (2016), the CoI framework relies on cognitive presence for successful online learning. Beckmann and Weber (2016) emphasized conducive learning environments as being motivating for students while promoting meaningful and worthwhile learning. Furthermore, Shea et al. (2003), in their research, realized that cognitive presence was important to students in terms of constructing and confirming meaning through sustained discourse in the CoI framework. Russo and Benson (2005) found that there was a growing pressure to identify online learning environments that contribute to or support learning. Russo and Benson (2005) further identified that social presence was critical to the development of the CoI framework and that it increased the likelihood of students to engage in and complete online classes. Mirabolghasemi et al. (2018) suggested that building a classroom community plays a significant role in blended learning courses, as exemplified by the use of technology to support blended courses and facilitate proper engagement with learning processes. Furthermore, Horn and Staker (2011) recognized that most growth occurring in contemporary learning environments necessitated blended learning environments in which students use technology to learn.

Applying the three presences of the CoI framework to design a blended learning environment can facilitate the connection between the learners and instructor by involving collaborative learning activities (Sutton, 2018). Kucuk and Sahin (2013) found a correlation between the three presences of the CoI framework and students’ academic achievement. Interestingly, they pointed out that teaching presence and social presence are shown to have a positive impact on students’ cognitive presence, increasing academic achievement (Garrison et al., 2010; Harrell & Wendt, 2019; Law et al., 2019; Vo et al., 2020). Pollard et al. (2014),
Chang-Tik (2018), and Cleveland-Innes et al. (2019) reported merging the three presences of the CoI framework to enhance learning and improve students’ performance. However, research regarding the effectiveness of the CoI framework when station rotation is the targeted form of blended learning is still limited, especially in elementary school settings (Hilliard, 2015). Therefore, this study adds to the general knowledge base about the impact of using the three presences of the CoI framework as a guide for designing and organizing the station rotation learning environment for effective learning of elementary mathematics in a K–12 setting.

Station Rotation Strategy and CoI Framework

To ensure that the CoI framework is a productive guide to design a station rotation learning environment, the teacher should create a deep and meaningful study experience with the students by developing three interdependent elements—teaching, social, and cognitive presence—to allow students to gain a deeper understanding of certain learning environments (Chen, 2018; Marjadi et al., 2017; Vaughan, 2010). Stations can include a variety of activities. The instructor designs various activities to help students engage with more than one way to practice their skills (Govindaraj & Silverajah, 2017; McCollum, 2019; Scott, 2007). Furthermore, the instructor can facilitate learning by ensuring that students participate in productive dialogue and new course concepts that reinforce a sense of community (Ayob et al., 2020; Hinkhouse, 2013; Mahalli et al. 2019; Truitt, 2016).

Moreover, social presence is one of the important keys to learner participation and success in online learning (Cheung, 2009; Jusoff & Rouhollah, 2009). It describes the ability of individuals to identify with the course and community (Akyol et al., 2009). Social presence is an important part of communication with students in and out of the classroom (Jusoff & Rouhollah,
2009; Pollard et al., 2014). Related literature indicates that social presence improves the quality of students’ performance (Almasi & Zhu, 2018; Borup et al., 2014; Garner & Rouse, 2016; Jusoff & Rouhollah, 2009; Whiteside, 2015;) and engagement (Armellini & De Stefani, 2016; So & Brush, 2008). Additionally, social presence is a function of the communication between the instructor and the learners (Lowenthal, 2010). A station rotation strategy may relate to the CoI social presence in several ways. For example, an instructor interacts with learners and students interact with their peers to improve instructional effectiveness and build a sense of community (Cui et al., 2013; Truitt & Ku, 2018). Additionally, creating discussion among learners online or face-to-face can make them comfortable and open, which can help to improve their performance (Brindley et al., 2009; Capdeferro & Romero, 2012; Chiong & Jovanovic, 2012) and develop group collaboration and communication skills (Pollard et al., 2014). Table 2 illustrates how the elements of the CoI framework align with the station rotation strategy.

Finally, cognitive presence is the core of the inquiry process to design online instruction (Garrison, 2003; McKerlich et al., 2011; Shea & Bidjerano, 2009). It begins with triggering an event and moves on to exploration, integration, and then resolution (Akyol et al., 2009; see Figure 3). In a station rotation setting, students are given different activities to engage at different times in while incorporating instructions from technology (Chen, 2018; Lee, 2014; Khader, 2016; Vega-Bajana, 2019). The use of technology in the station may include the opportunity for students to watch video lessons while learning the class content (Abdelhakam & Albarrak, 2015; Govindaraj & Silverajah, 2017; Mondragon et al., 2018). This approach can increase student participation in the classroom and improve student learning outcomes (Lim, 2015; McCollum, 2019; Nisa, 2018). It also provides a space for teaching presence and cognitive presence through

Table 2

Elements of the Community of Inquiry (CoI) Framework and Station Rotation Learning Strategy

<table>
<thead>
<tr>
<th>Components of Station Rotation</th>
<th>Components Community of Inquiry Framework</th>
<th>Alignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Station Label</td>
<td>Cognitive Presence</td>
<td></td>
</tr>
<tr>
<td>Teacher Led Instruction</td>
<td>Triggering Event</td>
<td>Instructor introduces a dilemma or problem that students can relate to their experience.</td>
</tr>
<tr>
<td>(Station 1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Students Working Individually</td>
<td>Exploration</td>
<td>Students work individually to understand the topic through various activities.</td>
</tr>
<tr>
<td>(Station 2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collaborative Activity</td>
<td>Integration</td>
<td>Students construct their knowledge based on pertinent information generated during the previous station and work with other students collaboratively.</td>
</tr>
<tr>
<td>(Station 3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer - Based Instruction</td>
<td>Resolution</td>
<td>In the final station, students apply what they have learned in the previous stations using computers.</td>
</tr>
<tr>
<td>(Station 4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teaching Presence</td>
<td>Design and Organization</td>
<td>Instructor determines how many stations need to be set up, where they will be, what students will be doing, and where and how students will learn, sets a time, and writes an instruction for each station.</td>
</tr>
<tr>
<td>(Stations 1,2,3,4)</td>
<td>Facilitating Discourse</td>
<td>Instructor designs various activities that can keep students motivated during the lesson.</td>
</tr>
<tr>
<td></td>
<td>Direct Instruction</td>
<td>Instructor delivers the content for each group, provides real-time feedback, leads a small group discussion, selects an appropriate method of using technology, and completes the assessment for the students.</td>
</tr>
<tr>
<td>Social presence</td>
<td>Open Communication</td>
<td>Instructor interacts with the learners online or face-to-face, and students interact with their peers.</td>
</tr>
<tr>
<td>(Stations 2,3,4)</td>
<td>Group Cohesion</td>
<td>Students have a chance to choose and interact with other participants to build a sense of belonging through face-to-face interaction or an online communication platform.</td>
</tr>
<tr>
<td></td>
<td>Affective Expression</td>
<td>Discussion among learners online or face-to-face can make them comfortable and open.</td>
</tr>
</tbody>
</table>
Chapter Summary

This chapter defined blended learning and its various forms, including station rotation, computer lab rotation, flipped classroom, and individual rotation. This chapter also highlighted the advantages of integrating blended learning modes of teaching into academics and their impact on students’ attitude to learning and their achievement. The use of technology, which is infused in blended learning, leads to positive results. Finally, the chapter discussed the CoI framework and its integration into the process of designing blended learning and station rotation learning environments.
CHAPTER 3

METHODOLOGY

The primary research methodology for this study was quantitative – specifically, a quasi-experimental design – and descriptive qualitative data were also collected. Quasi-experimental designs aim to evaluate interventions through selected participants for different conditions (Harris et al., 2006). The study examined the effect of using a station rotation strategy on students’ achievement, attitude, and educational presence in sixth-grade mathematics in the KSA. This chapter details the research methods used in this study, including research design, research questions and hypotheses, participants and sampling, instrumentation, threats to validity, ethical principles, research procedures, and analytic approach.

This study was conducted in two sixth-grade classes in a private primary school in Bisha, a city located in Assir in the southwestern region of the KSA. Both classes were taught by the same teacher. One class utilized traditional, teacher-driven instruction. The other class utilized the station rotation strategy of blended learning, which it implemented in 2019. The two groups in this study were naturally assembled collectives because the students could not be randomly assigned to instructional method groups (Campbell & Stanley, 1963).

Research Design

As mentioned previously, a quantitative method was the primary approach used for the research, which included a nonequivalent comparison group design with a pretest and a posttest
and a follow-up to the descriptive qualitative results (open-ended questions) to further explain the male students’ experience of learning mathematics through the station rotation strategy.

Nonequivalent comparison groups are “one of the most commonly used quasi-experimental designs in educational research” (Cohen et al., 2007, p. 283). Numeric data were collected using a survey instrument, and open-ended questions provided descriptive qualitative data to explore the students’ attitudes and perceptions of educational presence toward learning mathematics. Students’ attitudes were measured through two TIMSS constructs: Students Like Learning Mathematics and Students Confident in Mathematics. Students also were assessed on the three constructs of the CoI framework: teaching, social, and cognitive presence.

Finally, pretests and posttests in student achievement, attitudes toward mathematics, and students’ perceptions of educational presence were administered before and after the intervention, respectively, to investigate the effects of a station rotation strategy on students’ outcomes. Table 3 displays the nonequivalent comparison group design.

Table 3

<table>
<thead>
<tr>
<th>Group</th>
<th>Time 1</th>
<th>Treatment</th>
<th>Time 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intervention Group</td>
<td>O1</td>
<td>X1</td>
<td>O2</td>
</tr>
<tr>
<td>Comparison group</td>
<td>O3</td>
<td>X2</td>
<td>O4</td>
</tr>
</tbody>
</table>

Note. O1 = pretest for intervention group, O2 = posttest for intervention group, O3 = pretest for comparison group, O4 = posttest for comparison group, and X1 = station rotation instruction, and X2 = traditional face-to-face instruction.
Variables

The dependent variables were the students’ mathematics achievement, students’ attitude toward learning mathematics, and students’ perception of educational presence. The independent variable was the teaching method, which consisted of two approaches: 1) a station rotation strategy and 2) traditional face-to-face instruction. Figure 4 displays the research model for this study.

Figure 4. Research model.
Research Questions and Hypotheses

This study examined the effects of using a station rotation strategy on students’ achievement, attitude, and educational presence in their mathematics class. For this purpose, the following research questions and hypotheses were investigated by comparing pretest and posttest scores in achievement, attitude, and educational presence from students in traditional face-to-face instruction with those in a station rotation blended course:

1. Do sixth-grade Saudi Arabian students in a station rotation mathematics course show higher mathematics achievement than students in a traditional face-to-face instruction mathematics course?

2. Do sixth-grade Saudi Arabian students in a station rotation mathematics course show a more positive attitude toward learning mathematics than students in a traditional face-to-face instruction mathematics course?

3. Do sixth-grade Saudi Arabian students in a station rotation mathematics course show more positive perceptions of educational presence (perceptions of teaching presence, social presence, and cognitive presence) than students in a traditional face-to-face instruction mathematics course?

The following research hypotheses guided this study:

H1: The mean posttest achievement scores of students in a station rotation mathematics course will be higher than the mean scores of students receiving traditional-face to-face instruction.
H2: The mean posttest scores for the intervention group will be higher than the mean posttest scores for the comparison group in the TIMSS constructs Students Like Learning Mathematics and Students Confident in Mathematics.

H3: The mean posttest perceptions of educational presence scores of students in a station rotation mathematics course will be higher than the mean scores of students receiving traditional face-to-face instruction.

Participants and Sampling

This study focused on male students because of the comprehensive policy of gender segregation in the KSA; therefore, 50 male students were selected from a private primary school in Bisha, a city located in Assir in the southwestern region of the KSA. The school had two sixth-grade classes, each with 25 students. The two classes were randomly assigned by the math teacher as to either the intervention group or the comparison group. Students in Group 1 (the comparison group, $N = 25$) learned mathematics through a traditional strategy while Group 2 students (the intervention group, $N = 25$) learned mathematics through station rotation. The same teacher instructed both classes. The majority of students at the school were from Saudi Arabia, with an additional mix of students from various Arabic backgrounds, such as Egypt, Sudan, and Syria. All students had a middle-class family socioeconomic status, and their ages ranged from 13 to 14 years.

Instrumentation

The methods used to gather data included two achievement mathematics tests and TIMSS and CoI surveys that assessed the students’ attitudes toward mathematics and the students’
perceptions of educational presence. Each instrument was administered to students in both the intervention group and the comparison group.

**Achievement Test**

The achievement test was administered at the beginning (pretest) and at the end (posttest) of the study and included 20 multiple-choice items. The pretest (see Appendix A) and posttest (see Appendix B) measured the same mathematics skills, but with different items. The achievement test was designed by the sixth-grade mathematics teacher and was already in use as part of the classroom assessment. The test included 20 items, each worth 2.5 points, and the highest possible score for the test was 50 points. The achievement test assessed the following mathematics skills: fractions, solving proportions, and the basics of probability.

**Achievement Test Validity and Reliability**

To establish validity evidence, mathematics experts were asked to evaluate whether the items of measurement were appropriate to measure the achievement test’s objectives (Hardesty & Bearden, 2004) and to provide additional feedback for improvements to the achievement test design. The three experts were district supervisors responsible for supporting elementary-level mathematics teachers' classroom instruction. They provided their opinions and an indicted that the achievement test was appropriate to evaluate students' performance regarding the math skills. They did not recommend any changes to the test items or design.

To establish reliability evidence for the tests, I implemented a pilot study using the test-retest method by applying the tests on a sample from outside the study sample. The pilot study sample consisted of 44 male sixth-grade students from a different private elementary school with
similar demographics. The pilot study was administered in the students’ first week of sixth grade, and in the third week the test was re-administered to the same sample. A Pearson correlation coefficient was calculated for the two groups. Moreover, I computed a Kuder–Richardson 20 (KR-20) index (Kuder & Richardson, 1937) to assess the internal consistency of the pretest and posttest scores.

TIMSS Survey

The TIMSS is a study established by the International Association for the Evaluation of Educational Achievement that allows education systems to compare student achievement and perspectives on teaching and learning in science and mathematics worldwide in aid of establishing an effective education policy. TIMSS uses context surveys to study community, home, school, and classroom contexts in which science and mathematics learning takes place. The data is collected with the involvement of principals, parents, teachers, and students. Comparing the results of the surveys with the TIMSS achievement data gives insight into factors related to student achievement, which is a crucial aspect when developing educational policy. Through the means of a survey, TIMSS can collect information concerning students’ experience, instruction, and attitude toward learning mathematics and science (Martin et al., 2015).

Students’ achievement is highly connected to their attitude, and thus the primary curricular goal is to improve students’ attitude. As a result, TIMSS has been involved in measuring students’ attitudes toward mathematics since 1995. TIMSS uses several different scales to measure fourth-grade students’ attitude toward learning. These include Students Confident in Mathematics and Students Like Learning Mathematics.
Mathematics scale measures students’ intrinsic motivation to learn; the Students Confident in Mathematics scale measures subject-specific self-confidence (Hooper et al., 2015).

The current study used the TIMSS fourth-grade attitudes toward mathematics scales to assess the sixth-grade students’ attitude toward learning mathematics in the KSA. Specifically, the Students Like Learning Mathematics (SLM) and Students Confident in Mathematics (SCM) scales were used. These scales consisted of nine items for SLM and six items for SCM. The associated Likert items had the following response options: 4 = agree a lot, 3 = agree a little, 2 = disagree a little, and 1 = disagree a lot. Scores for negatively worded items were reverse coded. For example, “mathematics is boring” means that disagree a lot is assigned a score of 4, and agree a lot is assigned a score of 1. The total score for each subscale (SLM and SCM) was computed as the sum of item scores across the relevant subscale items.

The TIMSS attitudes toward mathematics scales have been shown to produce reliable scores. For example, Cronbach’s alpha has been calculated for the instrument in various countries and consistently shows values above .64, with reliability for Saudi Arabia .75 (Martin et al., 2015, p.15). Another study was carried out by Sabah et al. (2013) in which two reliability indices (person reliability and item reliability) were used to assess reliability of the TIMSS scale scores. Person reliability indices ranged between .64 and .89 for the nine selected countries. Additionally, according to Liu and Boone (2006), the construct validity of the TIMSS attitude toward mathematics instrument indicates the items are of high quality. The items for TIMSS attitudes toward mathematics are shown in Appendix C (Part 1).
The community of inquiry (CoI) framework, developed by Garrison et al. (2000), involves the three components of teaching, social, and cognitive presence. The CoI instrument, which comes from the CoI framework, is a survey developed and validated by Arbaugh et al. (2008), and the results support the use of the CoI instrument as a valid measure of teaching, social, and cognitive presence. The development of the CoI instrument was an opportunity to extend the existing discussion regarding the methods used by practitioners and researchers on the online learning environment (Arbaugh et al., 2008).

The current study used the CoI instrument that included the three constructs of the CoI framework: teaching, social, and cognitive presence. The CoI survey consisted of 18 items: ten items for teaching presence, three items for social presence, and five items for cognitive presence. The total score for each subscale (teaching, social, and cognitive presence) was computed as the sum of item scores across the relevant subscale items. The data collected from the CoI survey used five-category Likert items (1 = strongly disagree to 5 = strongly agree) because many research studies have indicated that five options provide a more robust and accurate measurement (Creswell, 2015). Moreover, several research studies have used five-category Likert items to assess constructs in the CoI framework (Abraham, 2013; Cadle, 2013; Hall, 2013; Moisey et al., 2016).

The CoI survey scales have been shown to produce reliable scores. According to Arbaugh et al. (2008), data obtained from studies using the CoI framework have been validated across time and with different samples in different settings. Arbaugh et al. (2008) tested a measure of the CoI framework using a multi-institutional sample. The data was collected from 287 graduate-
level students enrolled in education and business college. The Cronbach’s alpha showed internal consistency equal to .94 for teaching presence, .91 for social presence, and .95 for cognitive presence. Their findings showed that the scores resulting from the CoI suggest that the instrument provides valid, reliable, and effective scores for online learning environments.

Moreover, their results were consistent with many research studies, such as Abraham (2013), Cadle (2013), and Sutton (2018). The items associated with each construct are shown in Appendix C (Part 2).

Furthermore, Olpak and Çakmak (2018) examined reliability and validity evidence for scores obtained from Turkish universities. The participants included 1,150 students enrolled in online courses in three Turkish state universities. The value of Cronbach’s alpha was .96 for teaching presence, .97 for cognitive presence, and .95 for social presence.

**Threats to Validity**

One of the issues that might affect the validity of scores from the TIMSS and CoI instruments is back translation. Because this study was conducted in Saudi Arabia, where the spoken language is Arabic, the instrument content was translated from English to Arabic. To ensure the accuracy of the translated survey items, the original survey instrument was translated into Arabic and then sent to instructional technology experts who are fluent in both Arabic and English to translate it back to English. Then I matched the translated and the original survey items to ensure accuracy.

Additionally, random selection of participants was not an option; therefore, selection of participants from existing classes and random assignment of intact classes into comparison and intervention groups were threats validity. To address this issue, I applied a one-way analysis of
variance (ANOVA) model to see if there was a significant difference in mean pretest scores for mathematics ability between the two groups. Finally, attendance was another threat because there was a chance of some students withdrawing from the school or enrolling in school during implementation of the study.

**Open-Ended Items**

The open-ended items were included as a follow-up to the quantitative surveys to provide descriptive data about students’ perceptions of learning through the station rotation learning strategy. The open-ended items for this questionnaire were adapted from Andrew et al. (2015). The original questionnaire addressed enhancing the online learning experience in the classroom domain. The survey questions were adjusted to indicate the current context of using the station rotation strategy for sixth-grade mathematics. Also, in the process of adapting the questionnaire for this study, a few items were also taken from a similar study by Truitt (2016) and modified. For example, Truitt (2016) used the concept of blended learning to ask the students about their experience. In the current study, the items were modified to focus on the station rotation strategy instead of blended learning. The questionnaire was made up of three open-ended items (see Appendix C, Part 3). These items provided descriptive qualitative data about students’ experiences, perceptions of station rotation strategy, and suggestions to improve the station rotation classroom experience.
Ethical Principles / Human Subjects Compliance

Three areas of concern needed attention. The first factor was the age of the participants. The typical age of the students in the sixth grade is 13 to 14 years. I asked the parents to complete an opt-in permission (consent) form for parents/guardians of minors before conducting the study and completing the questionnaire (see Appendix D). In addition, to match pretest mathematics knowledge scores with posttest mathematics knowledge scores and mathematics performance scores to attitude scores for each student, I needed to collect data with identifying information (student name). Once the data files were matched, I removed the students’ names and started the analysis process. The privacy and security of the data were another concern. I took responsibility for ensuring the data were securely and safely stored to maintain the required confidentiality. I used SPSS to code the comparison group and intervention group, and all data were kept secure in a password-protected file on my private computer, which remained with me all the time.

Research Procedures

To conduct this study, I submitted an application to the Institutional Review Board (IRB) at Northern Illinois University. Following this, I sent a copy of the IRB approval to the Bisha School District in the KSA to obtain permission to conduct this study (see Appendix E). After I received approval from Bisha School District, the pilot study achievement tests and questionnaires were administered to students in the pilot school during their first week of sixth grade. The tests and questionnaires were re-administered to same students in the third week.
During the pilot study, the teacher at the experimental school distributed a permission form (see Appendix D) to the students to be given to the parents/guardians. After I collected the parental permission forms, students with permission were asked to indicate individual assent (see Appendix F), and after that, the achievement pretest (see Appendix A) and questionnaire (Appendix C, Parts 1, 2, and 3) were administered at the start of the eight-week intervention study.

Students in each class were taught five times a week by the same mathematics teacher, and each session was 45 minutes at different times and on different days. The lessons consisted of two units from sixth-grade mathematics books, and the duration of each unit was four weeks. Students in the comparison group did not have computer instruction, and the mathematics teacher used a lecture and individual activity strategies to deliver the content. The instructional materials in the comparison group included a textbook, whiteboard, and marker. Alternatively, students in the intervention group were taught through station rotation instruction in which students moved through various stations in the classroom with different information/sources during the lesson, with at least one of the stations using technology (see Figure 5). These students also assembled in small groups of five to seven to encourage group collaboration, and the mathematics teacher created various activities that helped provide different learning styles for all students at a station. Table 4 shows the activities that were applied in the station rotation mathematics lessons.

Finally, the achievement posttest (see Appendix B) and questionnaire (see Appendix C, Parts 1, 2, and 3) were administered in Week 11 after the eight-week study had been conducted to better assess students’ progress through the entire study.
Figure 5. Classroom arrangement for comparison group.

<table>
<thead>
<tr>
<th>Components of Station Rotation Strategy</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher-led instruction (Station 1)</td>
<td>Instructor introduces a dilemma or problem that students can relate to their experience.</td>
</tr>
<tr>
<td>Students working individually (Station 2)</td>
<td>Students work individually to understand the topic through various activities like brainstorming, learning challenges, or watching video.</td>
</tr>
<tr>
<td>Collaborative activity (Station 3)</td>
<td>Students construct their knowledge based on pertinent information generated during the previous station and working with other students collaboratively through various activities such as independent reading, workbook pages or other pencil-and-paper tasks, one-on-one tutoring, small-group work, projects, or games.</td>
</tr>
<tr>
<td>Computer based instruction (Station 4)</td>
<td>Students apply what they have learned in the previous stations through technology device.</td>
</tr>
</tbody>
</table>
Analytic Approach

To answer the three research questions and assess the three related hypotheses, I used the test scores as well as the attitude scales and educational presence scales. Data were entered into SPSS, and tests of inference were conducted to determine whether any statistically significant differences existed between the comparison and intervention groups. Specifically, a series of analyses of covariance (ANCOVA) were carried out in which the dependent variables were the posttest achievement test scores, posttest SLM and SCM attitudinal scores, and posttest CoI scores. The fixed factor was the type of class instruction (traditional vs. intervention), and the covariates were the pretest scores associated with the posttest scores of interest (e.g., for analysis using SLM posttest scores as the outcome, SLM pretest scores served as the covariate). Additionally, group differences in growth for each of the outcomes were assessed using mixed-design ANOVA, where the within-subjects factor was the time (pretest vs. posttest) and the between-subjects factor was the group (traditional vs. intervention). For all analyses, effect sizes (eta-squared) were computed as indices of effect size. Assessment of assumptions (i.e., normality of residuals, homogeneity of variances, and homogeneity of regression slopes) was carried out visually and statistically. Each test of statistical significance used an *a priori* alpha level of .05. SPSS software was used for data analysis.

Chapter Summary

A quantitative approach – specifically, a quasi-experimental design – and descriptive qualitative data were used to collect data from the participants. The primary purpose of this study was to examine the effect of using a station rotation strategy on sixth-grade mathematics
students’ achievement, attitudes toward learning mathematics, and perception of educational presence.

The participants were from a private primary school in Bisha, a city located in Assir in the southwestern region of the KSA. The research sample design involved random assignment into the intervention group and the comparison group. This study employed a survey with 27 items, adapted from TIMSS fourth-grade attitudes toward mathematics scales and CoI (Akyol et al., 2009; see Appendix G for the permission). The process of collecting the data from 50 male students took two months.
CHAPTER 4

RESULTS

The purpose of the current study was to examine the effect of using a station rotation strategy on sixth-grade mathematics students’ achievement, attitudes toward learning mathematics, and perception of educational presence. The study was conducted in the KSA. The quantitative approach was the primary phase and was followed by the collection of descriptive qualitative data (through open-ended questions) to further explain the results (Creswell, 2015; Creswell & Plano Clark, 2017). The following research questions were addressed:

1. Do sixth-grade Saudi Arabian students in a station rotation mathematics course show higher mathematics achievement than students in a traditional face-to-face mathematics course?

2. Do sixth-grade Saudi Arabian students in a station rotation mathematics course show a more positive attitude toward learning mathematics than students in a traditional face-to-face mathematics course?

3. Do sixth-grade Saudi Arabian students in a station rotation mathematics course show a more positive perspective of educational presence (perspective of teaching presence, social presence, and cognitive presence) than students in a traditional face-to-face mathematics course?
Description of the Sample

Two groups of sixth-grade students were selected to participate in this study. The first group was the intervention group, consisting of students who learned using the station rotation strategy. The second group was the comparison group, consisting of students who learned using a traditional teaching strategy. The sample size in each group was 25, and the students in each group were from various countries, including Saudi Arabia, Egypt, Sudan, and Syria.

Research Question 1 Findings

This section presents the findings of Research Question 1: Do sixth-grade Saudi Arabian students in a station rotation mathematics course show higher mathematics achievement than students in a traditional face-to-face mathematics course? An achievement test consisting of 20 multiple-choice items was administered at the beginning of the study (pretest) and at the conclusion of the study (posttest; see Appendices F and G). The achievement test was given during the math class, and the highest possible score for the test was 50 points.

Table 5 shows the descriptive statistics for the pretest and posttest achievement scores by group and for the overall sample. There were no observed extreme values, as seen in the boxplots for the scores (see Figures 6 and 7).
Table 5

Descriptive Statistics for Achievement Test Scores by Group

<table>
<thead>
<tr>
<th>Group</th>
<th>Achievement Pretest</th>
<th>Achievement Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$n$</td>
<td>$M$</td>
</tr>
<tr>
<td>Intervention Group</td>
<td>25</td>
<td>26.40</td>
</tr>
<tr>
<td>Comparison Group</td>
<td>25</td>
<td>24.58</td>
</tr>
</tbody>
</table>

Figure 6: Boxplot of achievement pretest scores for intervention and comparison groups.
Figure 7: Boxplot of achievement posttest scores for intervention and comparison groups.

One-way ANOVA was carried out on the pretest scores to assess whether the students in the two groups were similar in achievement level before the treatment. The results of this test (Table 6) showed no statistically significant difference in the pretest scores between the groups, $F(1, 49) = 0.63, p = .431$. Therefore, the two groups were considered to be at a statistically equivalent level of achievement at the implementation of the intervention. Based on results from Levene’s test, the homogeneity of variance assumption for this ANOVA was met ($p = .28$). Figure 8 shows the distribution of residuals. The residuals from the model did not differ significantly from a normal distribution based on the Shapiro–Wilk ($p = .468$) and Kolmogorov–Smirnov ($p = .200$) tests.
Table 6

Analysis of Variance (ANOVA) Test Results for Achievement Pretest

<table>
<thead>
<tr>
<th></th>
<th>Sum of squares</th>
<th>df</th>
<th>Mean square</th>
<th>F</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>41.40</td>
<td>1</td>
<td>41.40</td>
<td>0.63</td>
<td>.431</td>
</tr>
<tr>
<td>Within Groups</td>
<td>3152.84</td>
<td>48</td>
<td>65.68</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>3194.24</td>
<td>49</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 8: Histogram of the residuals from one-way analysis of variance (ANOVA) on pretest scores.

Effect of Intervention on Achievement Scores

To assess whether there was a mean difference in posttest achievement scores, controlling for pretest achievement scores, ANCOVA was carried out using posttest achievement
scores as the dependent variable, the pretest scores as the covariate, and the group (intervention vs. comparison group) as the between-subjects factor. Results from this ANCOVA (Table 7) showed that, after controlling for pretest score differences, there was a statistically significant difference between the two groups, $F(1, 49) = 38.89, p < .001$, with a large effect size ($\eta^2 = 0.38$) based on Cohen’s (1988) guidelines. Figure 9 shows a plot of the adjusted mean values. Based on the results of Levene’s test, the homogeneity of variance assumption was met ($p = .60$). Figure 10 shows the distribution of residuals. The residuals from the model did not depart significantly from a normal distribution based on either the Shapiro–Wilk ($p = .209$) or Kolmogorov–Smirnov ($p = .200$) test.

Table 7

Analysis of Covariance (ANCOVA) Test Results for Group Differences in Achievement Posttest Scores

<table>
<thead>
<tr>
<th>Source</th>
<th>Sum of squares</th>
<th>$df$</th>
<th>Mean square</th>
<th>$F$</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Achievement-Pretest</td>
<td>413.41</td>
<td>1</td>
<td>413.41</td>
<td>9.52</td>
<td>.003</td>
</tr>
<tr>
<td>Group</td>
<td>1689.22</td>
<td>1</td>
<td>1689.22</td>
<td>38.89</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Error</td>
<td>2041.08</td>
<td>47</td>
<td>43.42</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>4364.12</td>
<td>49</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 9: Histogram of the residuals from ANCOVA on posttest scores.

Figure 10: Adjusted mean achievement posttest scores by group.
Additionally, to assess whether a difference in mean growth was evident between the two groups, mixed-design ANOVA was carried out, with the time of the test (pretest vs. posttest) serving as the within-subjects factor and the group (intervention vs. comparison group) serving as the between-subjects factor. Results from this mixed-design ANOVA (Table 8) showed a statistically significant difference between groups in mean growth, $F(1, 48) = 20.05$, $p < .001$, with a large effect size (eta-squared = .19). Figures 11 and 12 show plots of the residuals for the pretest and posttest scores. Figure 13 shows the mean growth in posttest scores over time for the two groups. Based on Box’s test, the assumption of homogeneity of variance-covariance was not met ($p = .003$). However, the equality of sample sizes mitigated this concern. The residuals from the pretest scores did not differ significantly from a normal distribution based on both the Shapiro–Wilk test ($p = .468$) and the Kolmogorov–Smirnov test ($p = .200$). The posttest residuals did not depart significantly from a normal distribution based on either the Shapiro–Wilk ($p = .209$) or Kolmogorov–Smirnov ($p = .200$) test.

Table 8

Tests of Within-Subjects Effects for Achievement Test Scores

<table>
<thead>
<tr>
<th>Effect</th>
<th>Sum of squares</th>
<th>df</th>
<th>Mean Square</th>
<th>$F$</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>1216.60</td>
<td>1</td>
<td>1216.60</td>
<td>28.20</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Time × Group</td>
<td>694.32</td>
<td>1</td>
<td>694.32</td>
<td>20.05</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Error (Time)</td>
<td>1661.99</td>
<td>48</td>
<td>34.62</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 11: Histogram of residuals from mixed-design ANOVA on achievement pretest scores.

Figure 12: Histogram of residuals from mixed-design ANOVA on achievement posttest scores.
The results pertaining to Research Question 1 indicate that the mean posttest achievement scores for the intervention group were significantly and substantially higher than the mean posttest achievement scores for the comparison group. Additionally, the intervention group showed significantly and substantially greater growth in achievement test scores compared to the comparison group.

**Research Question 2 Findings**

This section presents the findings of Research Question 2: Do sixth grade Saudi Arabian students in a station rotation mathematics course show more positive attitude toward learning
mathematics than students in a traditional face-to-face mathematics course? To assess attitude
toward learning mathematics, the students responded to 18 Likert items (coded as 1 = strongly 
_disagree, 2 = disagree, 3 = agree, and 4 = strongly agree) related to two constructs: Students 
Like Learning Mathematics (SLM) and Students Confident in Mathematics (SCM). The overall 
reliability of the pretest and posttest survey scores was good, with Cronbach’s alpha values 
ranging between .83 and .92 (see Table 9).

<table>
<thead>
<tr>
<th>Measure</th>
<th>Pretest</th>
<th></th>
<th>Posttest</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Students Like Learning Mathematics (SLM)</td>
<td>Intervention</td>
<td>.88</td>
<td>Comparison</td>
<td>.87</td>
</tr>
<tr>
<td>Students Confident in Mathematics (SCM)</td>
<td>.80</td>
<td>.85</td>
<td>.83</td>
<td>.90</td>
</tr>
</tbody>
</table>

**Table 9**

Cronbach’s Alpha Coefficient Values for Constructs

Students Like Learning Mathematics

Table 10 shows descriptive statistics for the pretest and posttest Students Like Learning 
Mathematics scores by group and for the overall sample. There were no observed extreme 
values, as seen in the boxplots for the scores (see Figures 14 and 15).
Table 10

Descriptive Statistics for Students Like Learning Mathematics by Group

<table>
<thead>
<tr>
<th>Group</th>
<th>Pretest</th>
<th></th>
<th>Posttest</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>M</td>
<td>SD</td>
<td>n</td>
</tr>
<tr>
<td>Intervention Group</td>
<td>25</td>
<td>20.76</td>
<td>7.80</td>
<td>25</td>
</tr>
<tr>
<td>Comparison Group</td>
<td>25</td>
<td>20.16</td>
<td>6.63</td>
<td>25</td>
</tr>
</tbody>
</table>

Figure 14: Boxplot of Students Like Learning Mathematics pretest scores for intervention and comparison groups.
A one-way ANOVA was carried out on the pretest scores to assess whether the students in the two groups were similar in Students Like Learning Mathematics scores before the treatment. The results of this test (Table 11) showed that there was no statistically significant mean difference in the pretest scores between groups, $F(1.49) = 0.09, p = .771$. Therefore, the two groups were considered to be at a statistically equivalent level of achievement at the implementation of the intervention. Based on results from Levene’s test, the homogeneity of variance assumption for this ANOVA was met ($p = .27$). The residuals from the model did not differ significantly from a normal distribution based on the Shapiro–Wilk test ($p = .143$), but the Kolmogorov–Smirnov test did indicate significant departure from normality ($p = .047$). However, examination of the distribution of these residuals (Figure 16) did not indicate
substantial non-normality.

Table 11
ANOVA Test Results for Students Like Learning Mathematics (Pretest)

<table>
<thead>
<tr>
<th></th>
<th>Sum of squares</th>
<th>df</th>
<th>Mean square</th>
<th>F</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>4.50</td>
<td>1</td>
<td>4.50</td>
<td>0.09</td>
<td>.771</td>
</tr>
<tr>
<td>Within Groups</td>
<td>25115.92</td>
<td>48</td>
<td>52.42</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>2520.42</td>
<td>49</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 16: Histogram of the residuals from one-way ANOVA on pretest score.

Effect of Intervention on Students Like Learning Mathematics Scores

To assess whether there was a mean difference in Students Like Learning Mathematics posttest scores, controlling for the Students Like Learning Mathematics pretest scores,
ANCOVA was carried out using Students Like Learning Mathematics posttest scores as the dependent variable, the pretest scores as the covariate, and the group (intervention vs. comparison group) as the between-subjects factor. Results from this ANCOVA (Table 12) showed that, after controlling for pretest score differences, there was a statistically significant difference between the two groups, $F(1, 49) = 14.86, p < .001$, with a moderate effect size ($\eta^2 = 0.10$). Figure 17 shows a plot of the adjusted mean values. Based on the results of Levene’s test, the homogeneity of variance assumption was met ($p = .39$). Figure 18 shows the distribution of residuals. The residuals from the model did not differ significantly from a normal distribution based on either the Shapiro–Wilk ($p = .232$) or Kolmogorov–Smirnov ($p = .200$) test.

Table 12

ANCOVA Test Results for Group Differences in Students Like Learning Mathematics (SLM) Posttest Scores

<table>
<thead>
<tr>
<th>Source</th>
<th>Sum of squares</th>
<th>$df$</th>
<th>Mean square</th>
<th>$F$</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLM -Pretest</td>
<td>1172.48</td>
<td>1</td>
<td>1172.48</td>
<td>79.56</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Group</td>
<td>219.10</td>
<td>1</td>
<td>219.10</td>
<td>14.86</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Error</td>
<td>692.63</td>
<td>47</td>
<td>14.73</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>2129.62</td>
<td>49</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 17: Histogram of the residuals from ANCOVA (analysis of covariance) on posttest scores.

Figure 18: Adjusted Students Like Learning Mathematics posttest scores by group.
Additionally, to assess whether a statistically significant difference in mean growth was evident between the two groups, a mixed-design ANOVA was carried out, with the time of the test (pretest vs. posttest) serving as the within-subjects factor and the group (intervention vs. comparison group) serving as the between-subjects factor. Results from this mixed-design ANOVA (Table 13) showed a statistically significant difference between groups in mean growth, $F(1, 48) = 10.14, p = .003$, with a large effect size (eta-squared = .15). Figures 19 and 20 show plots of the residuals for pretest and posttest scores. Figure 20 shows the mean growth in posttest scores over time for the two groups. Based on Box’s test, the assumption of homogeneity of variance-covariance was met ($p = .859$). The residuals from the pretest scores did not differ significantly from a normal distribution based on the Shapiro–Wilk test ($p = .143$), but the Kolmogorov–Smirnov test did indicate significant departure from normality ($p = .047$). However, examination of the distribution of these residuals (Figure 21) did not indicate a substantial departure from normality. The posttest residuals did not depart significantly from a normal distribution based on either the Shapiro–Wilk ($p = .232$) or Kolmogorov–Smirnov ($p = .200$) test.

<table>
<thead>
<tr>
<th>Effect</th>
<th>Sum of squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>81.00</td>
<td>1</td>
<td>81.00</td>
<td>8.22</td>
<td>.006</td>
</tr>
<tr>
<td>Time × Group</td>
<td>100.00</td>
<td>1</td>
<td>100.00</td>
<td>10.14</td>
<td>.003</td>
</tr>
<tr>
<td>Error (Time)</td>
<td>473.00</td>
<td>48</td>
<td>9.854</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 19: Histogram of the residuals from mixed-design ANOVA on Students Like Learning Mathematics pretest scores.

Figure 20: Histogram of the residuals from mixed-design ANOVA on Students Like Learning Mathematics posttest scores.
Figure 21: Mean Students Like Learning Mathematics scores by group and time.

Students Confident in Mathematics

Table 14 shows descriptive statistics for the pretest and posttest Students Confident in Mathematics scores by group and for the overall sample. There were no observed extreme values, as seen in the boxplots for the scores (see Figures 22 and 23)

Table 14

Descriptive Statistics for Students Confident in Mathematics (SCM) by Group

<table>
<thead>
<tr>
<th>Group</th>
<th>Pretest</th>
<th></th>
<th></th>
<th>Posttest</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>M</td>
<td>SD</td>
<td>N</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Intervention</td>
<td>25</td>
<td>19.44</td>
<td>7.17</td>
<td>25</td>
<td>25.80</td>
<td>6.48</td>
</tr>
<tr>
<td>Group</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comparison</td>
<td>25</td>
<td>21.24</td>
<td>6.49</td>
<td>25</td>
<td>15.44</td>
<td>5.78</td>
</tr>
</tbody>
</table>
Figure 22: Boxplot Students Confident in Mathematics pretest scores for the intervention and comparison groups.

Figure 23: Boxplot of Students Confident in Mathematics posttest scores for the intervention and comparison groups.
A one-way ANOVA was carried out on the pretest scores to assess whether students across the groups were similar in achievement level before the treatment. The results of this test (see Table 15) show there was no statistically significant difference in the pretest scores between groups, $F(1.49) = 0.86$, $p = .357$. Therefore, the two groups were considered to be at an equivalent level of achievement at the implementation of the intervention. Based on results from Levene’s test, the homogeneity of variance assumption for this ANOVA was met ($p = .50$). Figure 24 shows the distribution of residuals. The residuals from the model did not differ significantly from a normal distribution based on the Shapiro–Wilk test ($p = .248$), but the Kolmogorov–Smirnov test indicated significant departure from normality ($p = .016$).

**Table 15**

ANOVA Test Results for Students Confident in Mathematics (SCM) Pretest

<table>
<thead>
<tr>
<th></th>
<th>Sum of squares</th>
<th>$df$</th>
<th>Mean square</th>
<th>$F$</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>40.50</td>
<td>1</td>
<td>40.50</td>
<td>0.86</td>
<td>.357</td>
</tr>
<tr>
<td>Within Groups</td>
<td>2248.72</td>
<td>48</td>
<td>46.84</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>2289.22</td>
<td>49</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Effect of Intervention on Students Confident in Mathematics Scores

To assess whether there was a mean difference in Students Confident in Mathematics posttest scores, controlling for Students Confident in Mathematics pretest scores, ANCOVA was carried out using posttest Students Confident in Mathematics scores as the dependent variable, the pretest scores as the covariate, and the group (intervention vs. comparison group) as the between-subjects factor. Results from this ANCOVA (Table 16) showed that, after controlling for pretest score differences, there was a statistically significant difference between the two groups, $F(1, 49) = 46.66, p < .001$, with a large effect size (eta-squared = 0.46). Figure 25 shows a plot of the adjusted mean values. Based on the results of Levene’s test, the homogeneity of variance assumption was met ($p = .31$). Figure 26 shows the distribution of residuals. The model residuals did not depart significantly from a normal distribution based on either the Shapiro–
Wilk \( (p = .078) \) or Kolmogorov–Smirnov \( (p = .200) \) test.

### Table 16

**ANCOVA Test Results for Group Differences in Students Confident in Mathematics (SCM) Posttest Scores**

<table>
<thead>
<tr>
<th>Source</th>
<th>Sum of squares</th>
<th>df</th>
<th>Mean square</th>
<th>( F )</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCM -Pretest</td>
<td>399.28</td>
<td>1</td>
<td>399.28</td>
<td>12.27</td>
<td>.001</td>
</tr>
<tr>
<td>Group</td>
<td>1517.91</td>
<td>1</td>
<td>1517.91</td>
<td>46.66</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Error</td>
<td>1528.88</td>
<td>47</td>
<td>32.52</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>3269.78</td>
<td>49</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 25: Histogram of the residuals from ANCOVA on posttest scores.
Additionally, to assess whether a statistically significant difference in mean growth was evident between the two groups, a mixed-design ANOVA was carried out with the time of the test (pretest vs. posttest) serving as the within-subjects factor and the group (intervention vs. comparison group) serving as the between-subjects factor. Results from this mixed-design ANOVA (Table 17) show a statistically significant difference between groups in mean growth, $F(661, 48) = 38.88, p < .001$, with a large effect size (eta-squared = 0.44). Figures 27 and 28 show plots of the residuals for the pretest and posttest scores. Figure 28 shows the mean growth in posttest scores over time for the two groups. Based on Box’s test, the assumption of homogeneity of variance-covariance was met ($p = .33$). The residuals from the pretest scores did not differ significantly from a normal distribution based on the Shapiro–Wilk test ($p = .248$), but the Kolmogorov-Smirnov test indicated a significant departure from normality ($p = .016$). However, examination of the distribution of these residuals (Figure 29) did not indicate
substantial departure from normality. The posttest residuals did not depart significantly from a normal distribution based on either the Shapiro–Wilk ($p = .078$) or Kolmogorov–Smirnov ($p = .200$) test.

Table 17
Tests of Within-Subjects Effects for Students Confident in Mathematics (SCM) Scores

<table>
<thead>
<tr>
<th>Effect</th>
<th>Sum of squares</th>
<th>df</th>
<th>Mean Square</th>
<th>$F$</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>1.96</td>
<td>1</td>
<td>1.96</td>
<td>0.08</td>
<td>.775</td>
</tr>
<tr>
<td>Time × Group</td>
<td>924.16</td>
<td>1</td>
<td>924.16</td>
<td>38.88</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Error (Time)</td>
<td>1140.88</td>
<td>48</td>
<td>23.76</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 27: Histogram of the residuals from mixed-design ANOVA on Students Confident in Mathematics pretest scores.
Figure 28: Histogram of the residuals from mixed-design ANOVA on Students Confident in Mathematics posttest scores.

Figure 29: Mean of Students Confident in Mathematics scores by group and time.
Summary of the Results

The results pertaining to Research Question 2 indicate that the mean posttest score for the intervention group was significantly and substantially higher than the mean posttest score for the comparison group in Students Like Learning Mathematics and Students Confident in Mathematics. Furthermore, the results showed a statistically significant and substantial difference between groups in mean growth.

Research Question 3 Findings

This section presents the findings of research question 3: Do sixth-grade Saudi Arabian students in a station rotation mathematics course show a more positive perspective of educational presence (perceptions of teaching presence, social presence, and cognitive presence) than students in a traditional face-to-face mathematics course? To assess perspective toward educational presence, the students responded to 18 Likert items (coded as 1 = *strongly disagree*, 2 = *disagree*, 3 = natural, 4 = *agree*, and 5 = *strongly agree*) related to three constructs: Teaching Presence (TS), Social Presence (SP), and Cognitive Presence (CP). The overall reliability of the survey scores for the pretest and posttest was good, with Cronbach’s alpha values ranging between .82 and .92 (see Table 18).
Table 18
Cronbach’s Alpha Coefficient Values for Constructs

<table>
<thead>
<tr>
<th>Measure</th>
<th>Pretest</th>
<th></th>
<th></th>
<th>Posttest</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intervention</td>
<td>Comparison</td>
<td>Intervention</td>
<td>Comparison</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teaching Presence (TP)</td>
<td>.90</td>
<td>.84</td>
<td>.92</td>
<td>.87</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social Presence (SP)</td>
<td>.83</td>
<td>.85</td>
<td>.90</td>
<td>.89</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cognitive Presence (CP)</td>
<td>.86</td>
<td>.82</td>
<td>.88</td>
<td>.91</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Teaching Presence

Table 19 shows the descriptive statistics for the pretest and posttest teaching presence scores by group and for the overall sample. There were no observed extreme values, as seen in the boxplots for the scores (Figures 30 and 31).

Table 19
Descriptive Statistics for Teaching Presence (TP) by Group

<table>
<thead>
<tr>
<th>Group</th>
<th>Pretest</th>
<th></th>
<th></th>
<th>Posttest</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>M</td>
<td>SD</td>
<td>N</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Intervention Group</td>
<td>25</td>
<td>24.36</td>
<td>9.21</td>
<td>25</td>
<td>41.40</td>
<td>6.43</td>
</tr>
<tr>
<td>Comparison Group</td>
<td>25</td>
<td>20.40</td>
<td>8.14</td>
<td>25</td>
<td>22.72</td>
<td>8.02</td>
</tr>
</tbody>
</table>
Figure 30: Boxplot of Teaching Presence pretest scores for intervention and comparison groups.

Figure 31: Boxplot of Teaching Presence posttest scores for intervention and comparison groups.
A one-way ANOVA was carried out on the pretest scores to assess whether students across the groups were similar in teaching presence level before the treatment. The results of this test (Table 20) showed no statistically significant difference in the pretest scores between the groups, $F(1.49) = 2.59, \ p = .114$. Therefore, the two groups were considered to be at an equivalent level of achievement at the implementation of the intervention. Based on results from Levene’s test, the homogeneity of variance assumption for this ANOVA was met ($p = .29$). The residuals from the model did not differ significantly from a normal distribution based on the Shapiro–Wilk test ($p = .123$), but the Kolmogorov–Smirnov test indicated significant departure from normality ($p = .018$). However, these residuals were not substantially non-normal (Figure 32).

Table 20

ANOVA Test Results for Teaching Presence (TP) Pretest

<table>
<thead>
<tr>
<th></th>
<th>Sum of squares</th>
<th>df</th>
<th>Mean square</th>
<th>$F$</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>196.02</td>
<td>1</td>
<td>196.02</td>
<td>2.59</td>
<td>.114</td>
</tr>
<tr>
<td>Within Groups</td>
<td>3631.76</td>
<td>48</td>
<td>75.66</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>3827.78</td>
<td>49</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Effect of Intervention on Students Perception of Teaching Presence Scores

To assess whether there was a mean difference in teaching presence posttest scores, controlling for pretest teaching presence scores, an ANCOVA was carried out using teaching presence posttest scores as the dependent variable, the pretest scores as the covariate, and the group (intervention vs. comparison group) as the between-subjects factor. Results from this ANCOVA (Table 21) show that, after controlling for pretest score differences, there was a statistically significant effect difference between the two groups, $F(1, 49) = 87.29$, $p < .001$, with a large effect size ($\eta^2 = 0.49$). Figure 33 shows a plot of the adjusted mean values. Based on the results of Levene’s test, the homogeneity of variance assumption was met ($p = .13$). Figure 34 shows the distribution of residuals. The model residuals did not depart significantly from a normal distribution based on either the Shapiro–Wilk ($p = .200$) or Kolmogorov–Smirnov ($p = .200$) test.
Table 21

ANCOVA Test Results for Group Differences in Teaching Presence (TP) Posttest Scores

<table>
<thead>
<tr>
<th>Source</th>
<th>Sum of squares</th>
<th>df</th>
<th>Mean square</th>
<th>F</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP -Pretest</td>
<td>711.25</td>
<td>1</td>
<td>711.25</td>
<td>18.26</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Group</td>
<td>3398.34</td>
<td>1</td>
<td>3398.34</td>
<td>87.29</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Error</td>
<td>1829.78</td>
<td>47</td>
<td>38.93</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>6902.82</td>
<td>49</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 33: Histogram of the residuals from ANCOVA on posttest scores.
Figure 34: Adjusted mean teaching presence posttest scores by group.

In addition, to assess whether a statistically significant difference in mean growth was evident between the two groups, a mixed-design ANOVA was carried out, with the time of the test (pretest vs. posttest) serving as the within-subjects factor and the group (intervention vs. comparison group) serving as the between-subjects factor. Results from this mixed-design ANOVA (Table 22) show a statistically significant difference between groups in mean growth, \( F(1, 48) = 43.95, p < .001 \), with a large effect size (eta-squared = 0.26). Figures 35 and 36 show plots of the residuals for pretest and posttest scores. Figure 36 shows the mean growth in posttest scores over time for the two groups. Based on Box’s test, the assumption of homogeneity of variance-covariance was not met \( (p = .001) \). However, the equality of sample sizes mitigated this concern. The residuals from the pretest scores did not differ significantly from a normal distribution based on the Shapiro–Wilk test \( (p = .123) \), but the Kolmogorov–Smirnov test indicated significant departure from normality \( (p = .018) \). However, examination of the
distribution of residuals (Figure 37) did not indicate substantial departure from normality. The posttest residuals did not depart significantly from a normal distribution based on either the Shapiro–Wilk \( (p = .200) \) or Kolmogorov–Smirnov \( (p = .200) \) test.

### Table 22

Tests of Within-Subjects Effects for Teaching Presence Scores

<table>
<thead>
<tr>
<th>Effect</th>
<th>Sum of squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>2342.56</td>
<td>1</td>
<td>2342.56</td>
<td>76.01</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Time × Group</td>
<td>1354.24</td>
<td>1</td>
<td>1354.24</td>
<td>43.95</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Error (Time)</td>
<td>1479.20</td>
<td>48</td>
<td>30.81</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 35: Histogram of the residuals from mixed-design ANOVA on pretest scores.
Figure 36: Histogram of the residuals from mixed-design ANOVA on posttest scores.

Figure 37: Mean teaching presence scores by group and time.
Social Presence

Table 23 shows descriptive statistics for the social presence pretest and posttest scores by group and for the overall sample. There were no observed extreme values, as seen in the boxplots for the scores (Figures 38 and 39).

Table 23
Descriptive Statistics for Social Presence (SP) by Group

<table>
<thead>
<tr>
<th></th>
<th>Pretest</th>
<th></th>
<th></th>
<th>Posttest</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>M</td>
<td>SD</td>
<td>N</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Group</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intervention</td>
<td>25</td>
<td>9.48</td>
<td>2.34</td>
<td>25</td>
<td>12.36</td>
<td>1.82</td>
</tr>
<tr>
<td>Comparison</td>
<td>25</td>
<td>9.92</td>
<td>2.13</td>
<td>25</td>
<td>8.68</td>
<td>1.43</td>
</tr>
</tbody>
</table>

Figure 38: Boxplot of Social Presence pretest scores for intervention and comparison groups.
A one-way ANOVA was carried out on the pretest scores to assess whether students across the groups were similar in terms of social presence before the treatment. The results of this test (Table 24) show no statistically significant mean difference in the pretest scores between groups, $F(1, 49) = 0.46, p = .501$. Therefore, the two groups were considered to be at a statistically equivalent level of achievement at the implementation of the intervention. Based on results from Levene’s test, the homogeneity of variance assumption for this ANOVA was met ($p = .48$). The residuals from the model did not significantly differ from a normal distribution based on the Shapiro–Wilk test ($p = .245$), but the Kolmogorov–Smirnov test indicated significant departure from normality ($p = .047$). However, this non-normality was not substantial (Figure 40).
Table 24

ANOVA Test Results for Social Presence (SP) Pretest

<table>
<thead>
<tr>
<th></th>
<th>Sum of squares</th>
<th>df</th>
<th>Mean square</th>
<th>F</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>2.42</td>
<td>1</td>
<td>2.42</td>
<td>0.46</td>
<td>.501</td>
</tr>
<tr>
<td>Within Groups</td>
<td>252.08</td>
<td>48</td>
<td>5.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>3254.50</td>
<td>49</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 40: Histogram of the residuals from one-way ANOVA on pretest scores.

Effect of Intervention on Students’ Perception of Social Presence

To assess whether there was a mean difference in social presence posttest scores, controlling for social presence pretest scores, ANCOVA was carried out using the social presence posttest as the dependent variable, the pretest scores as the covariate, and the group (intervention vs. comparison group) as the between-subjects factor. Results from this ANCOVA
Table 25

ANCOVA Test Results for Group Differences in Social Presence (SP) Posttest Scores

<table>
<thead>
<tr>
<th>Source</th>
<th>Sum of squares</th>
<th>df</th>
<th>Mean square</th>
<th>$F$</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP -Pretest</td>
<td>511.25</td>
<td>1</td>
<td>511.25</td>
<td>1.24</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Group</td>
<td>172.32</td>
<td>1</td>
<td>172.32</td>
<td>64.35</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Error</td>
<td>125.86</td>
<td>47</td>
<td>2.68</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>2129.62</td>
<td>49</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 41: Histogram of the residuals from ANCOVA on posttest scores.
Figure 42: Adjusted mean social presence posttest scores by group.

Additionally, to assess whether a statistically significant difference in mean growth was evident between the two groups, a mixed-design ANOVA was carried out with the time of the test (pretest vs. posttest) serving as the within-subjects factor and the group (intervention vs. comparison group) serving as the between-subjects factor. Results from this mixed-design ANOVA (Table 26) showed a statistically significant difference between the groups in mean growth, $F(1, 48) = 31.51, p < .001$, with a large effect size (eta-squared = 0.37). Figures 43 and 44 show the plots of the residuals for the pretest and posttest scores. Figure 44 shows the mean growth in posttest scores over time for the two groups. Based on Box’s test, the assumption of homogeneity of variance-covariance was met ($p = .624$). The residuals from the pretest scores did not differ significantly from a normal distribution based on the Shapiro–Wilk test ($p = .245$).
but the Kolmogorov–Smirnov test indicated a significant departure from normality ($p = .047$).

Examination of the distribution of residuals (Figure 45), however, did not indicate substantial departure from normality. The posttest residuals did not depart significantly from a normal distribution based on the Shapiro–Wilk test ($p = .096$), but the Kolmogorov–Smirnov test indicated significant departure from normality ($p = .006$). However, examination of the distribution of residuals (Figure 45) did not indicate a substantial departure from normality.

**Table 26**

Tests of Within-Subjects Effects for Social Presence (SP) Scores

<table>
<thead>
<tr>
<th>Effect</th>
<th>Sum of squares</th>
<th>df</th>
<th>Mean Square</th>
<th>$F$</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>16.81</td>
<td>1</td>
<td>16.81</td>
<td>4.99</td>
<td>.030</td>
</tr>
<tr>
<td>Time × Group</td>
<td>106.09</td>
<td>1</td>
<td>106.09</td>
<td>31.51</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Error (Time)</td>
<td>161.60</td>
<td>48</td>
<td>3.36</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 43: Histogram of the residuals from mixed-design ANOVA on social presence pretest scores.
Figure 44: Histogram of the residuals from mixed-design ANOVA on social presence posttest scores.

Figure 45: Mean social presence scores by group and time.
Cognitive Presence

Table 27 shows the statistics for the cognitive presence pretest and posttest scores by group and for the overall sample. There were no observed extreme values, as seen in the boxplots for the scores (Figures 46 and 47).

Table 27
Descriptive Statistics for Cognitive Presence (CP) by Group

<table>
<thead>
<tr>
<th>Group</th>
<th>Pretest</th>
<th>Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>M</td>
</tr>
<tr>
<td>Intervention Group</td>
<td>25</td>
<td>17.04</td>
</tr>
<tr>
<td>Comparison Group</td>
<td>25</td>
<td>18.72</td>
</tr>
</tbody>
</table>

Figure 46: Boxplot of Cognitive Presence pretest scores for intervention and comparison groups.
A one-way ANOVA was carried out on the pretest scores to assess whether students across the groups were similar in their cognitive presence level before the treatment. The results of this test (Table 28) show no statistically significant difference in the pretest scores between groups, $F(1, 49) = 1.92, p = .172$. Therefore, the two groups were considered to be at a statistically equivalent level of achievement at the implementation of the intervention. Based on results from Levene’s test, the homogeneity of variance assumption for this ANOVA was met ($p = .50$). Figure 48 shows the distribution of residuals. The residuals from the model did not differ significantly from a normal distribution based on both Shapiro–Wilk ($p = .416$) and Kolmogorov–Smirnov ($p = .200$) tests.
Table 28

ANOVA Test Results for Cognitive Presence (CP) Pretest

<table>
<thead>
<tr>
<th>Sum of squares</th>
<th>df</th>
<th>Mean square</th>
<th>F</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>35.28</td>
<td>1</td>
<td>35.28</td>
<td>1.92</td>
</tr>
<tr>
<td>Within Groups</td>
<td>2644.72</td>
<td>48</td>
<td>51.38</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>2644.72</td>
<td>49</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 48: Histogram of the residuals from one-way ANOVA on pretest scores.

Effect of Intervention on Students’ Perception of Cognitive Presence

To assess whether there was a mean difference in cognitive presence posttest scores, controlling for cognitive presence pretest scores, an ANCOVA was carried out using cognitive presence posttest scores as the dependent variable, the pretest scores as the covariate, and the
group (intervention vs. comparison group) as the between-subjects factor. Results from this ANCOVA (Table 29) show that, after controlling for pretest score differences, there was a statistically significant effect difference between the two groups $F(1, 49) = 8.41, p < .006$, with a large effect size ($\eta^2 = 0.13$). Figure 49 shows a plot of the adjusted mean values. Based on the results of Levene’s test, the homogeneity of variance assumption was met ($p = .07$).

Figure 50 shows the distribution of the residuals. The model residuals did not depart significantly from a normal distribution based on either the Shapiro–Wilk ($p = .219$) or the Kolmogorov–Smirnov ($p = .090$) test.

<table>
<thead>
<tr>
<th>Source</th>
<th>Sum of squares</th>
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<th>Mean square</th>
<th>$F$</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP -Pretest</td>
<td>130.22</td>
<td>1</td>
<td>130.22</td>
<td>9.57</td>
<td>.003</td>
</tr>
<tr>
<td>Group</td>
<td>114.47</td>
<td>1</td>
<td>114.47</td>
<td>8.41</td>
<td>.006</td>
</tr>
<tr>
<td>Error</td>
<td>639.13</td>
<td>47</td>
<td>13.59</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>843.78</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 49: Histogram of the residuals from ANCOVA on posttest scores.
In addition, to assess whether a statistically significant difference in mean growth was evident between the two groups, a mixed-design ANOVA was carried out with the time of the test (pretest vs. posttest) serving as the within-subjects factor and the group (intervention vs. comparison group) serving as the between-subjects factor. Results from this mixed-design ANOVA (Table 30) show a statistically significant difference between the groups in mean growth, $F(1, 48) = 10.47, p = .002$, with a large effect size (eta-squared = 0.16). Figures 51 and 52 show the plots of the residuals for the pretest and posttest scores. Figure 53 shows the mean growth in posttest scores over time for the two groups. Based on Box’s test, the assumption of homogeneity of variance-covariance was met ($p = .090$). The residuals from the pretest scores did not differ significantly from a normal distribution based on either the Shapiro–Wilk test ($p = .416$) or the Kolmogorov–Smirnov test ($p = .200$). Similarly, the posttest residuals did not depart
significantly from a normal distribution based on either the Shapiro–Wilk ($p = .219$) or Kolmogorov–Smirnov ($p = .090$) test.

Table 30

Tests of Within-Subjects Effects for Cognitive Presence (CP) Scores

<table>
<thead>
<tr>
<th>Effect</th>
<th>Sum of squares</th>
<th>df</th>
<th>Mean Square</th>
<th>$F$</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>56.25</td>
<td>1</td>
<td>56.25</td>
<td>5.55</td>
<td>.023</td>
</tr>
<tr>
<td>Time × Group</td>
<td>106.09</td>
<td>1</td>
<td>106.09</td>
<td>10.47</td>
<td>.002</td>
</tr>
<tr>
<td>Error (Time)</td>
<td>486.16</td>
<td>48</td>
<td>10.12</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 51: Histogram of the residuals from mixed-design ANOVA on cognitive presence pretest scores.
Figure 52: Histogram of the residuals from mixed-design ANOVA on cognitive presence posttest scores.

Figure 53: Mean cognitive presence scores by group and time.
Summary of Quantitative Results

The results pertaining to Research Question 3 indicate that the mean posttest score for the intervention group was significantly and substantially higher than the mean posttest score for the comparison group in teaching presence, social presence, and cognitive presence. Additionally, the intervention group showed significantly and substantially greater perceptions of educational presence than the comparison group. Finally, the results of teaching presence, social presence, and cognitive presence showed a statistically significant difference between groups in mean growth.

Descriptive Qualitative Questions Findings

The examination of the open-ended question data was conducted as a follow-up to the quantitative results and used to provide summaries on descriptive qualitative data about students’ perceptions of learning through the station rotation learning strategy. The questionnaire included three open-ended questions (see Appendix D, Part 3). The following questions were answered by 25 students:

1. What do you like the most about station rotation?

2. What do you like the least about station rotation?

3. Do you feel like you learn more or less during station rotation strategy than you do during the regular class time? Why?

Results Pertaining to Query 1

In the first query, the students were asked what they liked the most about station rotation.
There were varied answers, and 70% of the students chose these top three topics: the aspects of using technology, blended learning was fun, and they were able to learn. In the survey, 22 students indicated that learning using a computer was the most interesting aspect of station rotation. As one student put it, “I like the station rotation teaching strategy because I can use my computer.” Similarly, 20 students mentioned that station rotation was fun. For example, one student said, “With station rotation strategy style, the learning became fun.” The final common response concerned the students’ learning experience. Nineteen students indicated they like to learn through station rotation. One student mentioned how this strategy helped him gain knowledge of math: “The station rotation strategy helped me to learn in three ways: learning by myself, learning by computer, and learning with my friend.”

**Results Pertaining to Query 2**

The second query asked students what they liked the least about station rotation. Twenty percent of students had time management as their main answer to this question. The station rotation teaching strategy requires that every student rotate to every station. While moving among the stations, the students do some activities such as watching videos and completing exercises. However, the students sometimes could not accomplish their learning tasks. For example, one of the students pointed out, “I wish I had more time to do each activity for each station.” Another student said, “The math teacher asked [us] to do many activities for the three stations, but we did not have enough time to do it.”
Results Pertaining to Query 3

The third query the students were presented with asked them whether they feel that they learn more or less during station rotation strategy than during the regular class time and why. Of the responses, 23 of the students said they learned more during the station rotation class than they would have in the traditional class. One of the students said, “I learn more in station rotation learning strategy than the regular class because I use computer and do many activities.” Another student commented, “I prefer to participate in the station rotation learning strategy because the teacher uses different way to teach us in the class.” Only three students mentioned that they learned more by being in a traditional classroom. One student said, “Learning by computer takes more time than listening to the teacher during the math lesson.” Another student said, “I like to learn in the traditional classroom math because I did not know how to use the computer.”

Summary of Qualitative Results

The results pertaining to the first query indicate the students liked station rotation because they could use technology, the learning environment was enjoyable, and they were able to learn more. However, the results pertaining to the second query showed the time needed to complete each station activity was one of the obstacles of station rotation. Finally, the results pertaining to the third query indicated that most of the students liked to learn during station rotation strategy more than during the regular class activities because they could use computers for learning and the math teacher provided different ways to learn at each station.
The purpose of the current study was to examine whether utilizing a blended learning strategy would improve students' performance and attitudes toward learning mathematics in the context of sixth-grade education in the KSA. This study utilized the quantitative methodology – specifically, a quasi-experimental design using two surveys and descriptive qualitative open-ended questions – to address the stated research questions.

The findings support all three research hypotheses. The results suggest that students in a station rotation mathematics course show higher mathematics achievement than students in a traditional face-to-face mathematics course, show a more positive attitude toward learning mathematics than students in a traditional face-to-face mathematics course, and show a more positive perspective of educational presence (perspective of teaching presence, social presence, and cognitive presence) than students in a traditional face-to-face mathematics course. Moreover, the results show that implementing a station rotation strategy may lead to an improvement in students' achievement, attitude, and educational presence within the mathematics classroom.

In the following sections, the findings for each research question are discussed in detail in relation to previous research studies. Additionally, the effects of station rotation strategy and the implications, limitations, and recommendations for future research are discussed.
Research Question 1

- Do sixth-grade Saudi Arabian students in a station rotation mathematics course show higher mathematics achievement than students in a traditional face-to-face instruction mathematics course?

- H1: The mean posttest achievement scores of students in a station rotation mathematics course will be higher than the mean scores of students receiving traditional face-to-face instruction.

The purpose of the first research question was to examine the impact of a station rotation strategy by comparing students' achievement between the intervention and comparison groups. The findings showed a statistically significant difference in the posttest mean score from the ANCOVA test comparing the intervention and comparison groups. This difference indicated that the intervention group's posttest achievement scores were significantly higher than the mean posttest achievement scores for the comparison group. Additionally, the results showed a statistically significant difference between groups in mean growth. This finding supports the stated hypothesis that the station rotation learning strategy improves the students' achievement scores compared to a traditional approach for learning mathematics. This result is in agreement with previous research conducted by Ayob et al. (2020), Jones (2004), Kazakoff et al. (2018), Ocak (2010), and Truitt (2016), who found that the academic achievement levels of those who were taught using the station rotation strategy were significantly higher than those taught using traditional face-to-face instruction.

The current findings showed that learners' collaboration at different stations through collective curiosity and knowledge discovery may improve performance. The results of the
current study are also in alignment with the CoI framework, which aims to create communities of learners where students can collaborate, discover, and create understanding (Mirabolghasemi et al., 2018; Wang & Chen, 2008). The CoI framework was utilized to plan the station rotation strategy to increase the students’ performance for learning mathematics. A station rotation strategy provided an improvement-based teaching strategy when considering the teaching presence aspect of the CoI framework in several ways. The instructor plays a role in determining what students are supposed to do through engaging them in multiple activities that relate to the same skills (Kazakoff et al., 2018; McCollum, 2019; Vaughn & Garrison, 2005). For example, the instructor designed various activities that kept students engaged during the lesson at each station. Studies have shown a significant correlation between student engagement and their academic performance (Ainley & Ainley, 2011; Gunuc, 2014; Lee, 2014). Furthermore, the station rotation strategy enabled the instructor to work with smaller groups of students at a time, thus potentially providing more opportunities for the instructor to work with every student without trying to meet all students’ needs at one time (Fazal & Bryant, 2019; Mondragon et al., 2018; Nagy & Mohammed, 2018). For example, Mondragon et al. (2018) highlighted that providing additional time led to learners’ heightened enthusiasm for answering peer questions, collaborating to solve challenges, and handling different tasks in a station rotation strategy.

Moreover, the current results showed that applying cognitive presence to organizing different stations that involved a small learning community led by teacher instruction, where students worked individually, completed collaborative activities, and watched instructional videos, helped students to improve their performance in the mathematics course (Hesse, 2017; Kleber, 2015; Truitt, 2016). Additionally, students in the station rotation learning environments had the opportunity to learn individually, which helped students to have some control over their
learning and helped the instructor increase the time for those who needed more support (Kazakoff et al., 2018; Truitt, 2016). Therefore, combining teaching and cognitive presence aspects of the CoI framework to design the station rotation strategy created a deep and meaningful learning experience for students when compared to traditional face-to-face instruction.

Overall, the results from the current study suggest that the utilization of a station rotation strategy proved effective for students, resulting in higher scores on the achievement test and suggesting that teachers in the KSA may be able to use the station rotation strategy to improve student achievement on international mathematics tests.

Research Question 2

- Do sixth-grade Saudi Arabian students in a station rotation mathematics course show more positive attitude toward learning mathematics than students in a traditional face-to-face instruction mathematics course?
- H2: The mean posttest scores for the intervention group will be higher than the mean posttest scores for the comparison group in the TIMSS constructs Students Like Learning Mathematics and Students Confident in Mathematics.

The second research question's purpose was to understand whether attitudes toward learning mathematics for students in the station rotation strategy were more positive when compared to students in the traditional face-to-face instruction. The findings showed a statistically significant difference in the posttest mean score from the ANCOVA test comparing the intervention and comparison groups. This statistical difference indicated that learners in the intervention group expressed a more positive attitude towards learning mathematics than learners
in the comparison group. This result supports the stated hypothesis that the station rotation learning strategy improves the students’ attitude compared to traditional face-to-face instruction for learning mathematics. This finding is in agreement with previous research conducted by Holbeck and Hartman (2018), Kazakoff et al. (2018), and Tempelaar et al. (2012), in which they found that the students’ attitude toward learning in groups that were taught using the station rotation strategy was significantly higher than those taught using traditional face-to-face instruction.

In this study, the students in the station rotation strategy showed higher attitude scores for learning mathematics. Using the cognitive and social presences of the CoI framework to design the station rotation strategy helped to increase the students’ attitude towards learning mathematics in several ways. For example, cognitive presence was used to design the various station activities, and one of the reasons station rotation strategy contributes to positive outcomes is that students engage more easily when technology is integrated in activities (Al-Rimawi, 2014; Khader, 2016; Maccoun, 2016; Vega-Bajana, 2019). Computer-enhanced learning continues to take various forms, from using the computer in teaching to utilization of the internet, and currently, the concept of blended learning entirely depends on technology to facilitate learning (Lee, 2014; Setyaningrum, 2018; Waynick, 2015). The high level of interoperability between educational technology and station rotation strategy ensures that students can easily access learning materials and their instructors remotely, thereby promoting the continuation of learning and understanding (Lin & Wang, 2012; Nisa, 2018; Tucker, 2012; Wang et al., 2016).

Group work and interaction with peers, aspects of social presence, may be another reason the students in the station rotation strategy showed higher scores for attitude toward learning mathematics. This finding is in agreement with previous research conducted by Govindaraj and
Silverajah (2017), Kavadella et al. (2012), Lim (2015), and McCollum (2019), which indicated that there is significant positive relationship between students’ attitude and learning in a station rotation strategy environment. Moreover, the interaction between instructor and learners could be seen at the discussion station, which helped them to be more comfortable and open. The interaction between instructor and students improved instructional effectiveness and students’ attitude toward learning. This finding is also in agreement with previous research conducted by Cui et al. (2013) and Truitt and Ku (2018).

Therefore, this combination of the CoI framework and station rotation strategy is conducive to providing an effective learning environment and improving students’ attitude, which enhances engagement and confidence for sixth-grade students in the KSA for learning mathematics.

Research Question 3

- Do sixth-grade Saudi Arabian students in a station rotation mathematics course show more positive perceptions of educational presence (perceptions of teaching presence, social presence, and cognitive presence) than students in a traditional face-to-face instruction mathematics course?
- H3: The mean posttest perceptions of educational presence scores of students in a station rotation mathematics course will be higher than the mean scores of students receiving traditional face-to-face instruction.

The purpose of this research question was to examine whether students in a station rotation mathematics course showed a more positive educational presence than students in a traditional face-to-face mathematics course. The findings of this study indicated that the perceptions of
educational presence posttest scores among students in a station rotation mathematics course were higher than those who received traditional face-to-face instruction. This difference indicated that the students in the intervention group showed a more positive perspective of educational presence (i.e., teaching presence, social presence, and cognitive presence) when compared to students in a face-to-face instruction course. The impact of teaching, cognitive, and social presence on the students’ perceptions is discussed below.

**Teaching Presence**

Teaching presence improves the students' perceptions of learning, engagement, and performance in the station rotation strategy learning environment. The findings revealed a statistically significant difference in the posttest mean score from the ANCOVA test comparing the intervention and comparison groups. This difference indicated that the students learning in a station rotation environment showed higher scores in teaching presence than students in a traditional face-to-face instruction mathematics course. This finding is supported by earlier studies on the role of teaching presence in student perceptions of learning and engagement in blended learning that indicated that teaching presence has a positive effect in the blended learning environment (Baker, 2010; Law et al., 2019; Russo & Benson, 2005; Shea et al., 2003).

The current findings indicated that utilizing a station rotation strategy transforms a teacher's role through the design of the course, facilitation of discourse, and direct instruction. This finding supports earlier studies that have highlighted the crucial role of teaching presence in designing an effective online learning environment and improving the effectiveness and flexibility of teaching (Anderson et al., 2001; Chen, 2018; Garrison & Cleveland-Innes, 2005; Staker & Horn, 2012). Through the design of the course and direct instruction of teaching
presence, the instructor described the planning, explained to the students how the stations needed
to be set up and how students would learn, wrote instructions for each station, provided real-time
feedback, and delivered the content for each group. Garrison (2009) pointed out that teachers
need to facilitate the following relationships for the blended learning environment: student–
instructor, student–peer, and student–material. For the facilitating discourse, as the teacher
engaged learners through various activities, the current findings indicate that the interactions
between the teacher and students in the station rotation classroom increased and promoted
learning more than traditional face-to-face instruction. These findings are in agreement with
previous research conducted by Prescott et al. (2018) and Chen (2018), which highlighted that
incorporating teaching presence in blended learning activities such as small collaborative groups,
individual work, and technology improves students’ academic achievement.

These findings showed the effectiveness of CoI teaching presence as an instructional
framework to design the station rotation classroom lessons, which mathematics instructors can
apply to improve students’ performance.

Social Presence

Social presence promotes the development of a positive learning environment that in turn
promotes improved learning among students in a station rotation strategy. The findings of the
current study showed a statistically significant difference in the posttest mean score from the
ANCOVA test comparing the intervention and comparison groups. This difference indicated that
students in a station rotation strategy had a more positive perception of social presence than
students in a traditional face-to-face instruction mathematics course. Additionally, the current
study results indicated that social presence had a significant influence on student performance
and engagement in the station rotation strategy classroom. This finding is supported by various past studies, including Almasi and Zhu (2018), Garner and Rouse (2016), Hostetter (2013), Karadeniz (2018), Lim and Richardson (2016), and Oyarzun et al. (2018), which indicated that there is a significant relationship between social presence and the improvement of students’ performance.

The current study results also showed social presence promotes effective expression, better communication, and improved group collaboration among the learners in a station rotation, thus improving social relations and learning from one another. Interestingly, social presence has been found to be positively correlated with students’ positive perception toward learning in the blended learning environment (Hesse, 2017; Horzum, 2017; Izmirli & Izmirli, 2019; Nolan-Grant, 2019; Oyarzun et al., 2018; Robb & Sutton, 2014; Waynick, 2015; Weidlich & Bastiaens, 2019; Yilmaz et al., 2013; Zhan & Mei, 2013). Moreover, the study's findings show that students in the station rotation demonstrate increased engagement in learning due to interaction in different activities. This finding is supported by Capdeferro and Romero (2012), Chiong and Jovanovic (2012), Richardson et al. (2017), and Romanoski (2020), who pointed out that creating activities such as discussion among learners increases the students’ interaction and that students had positive attitudes towards online learning in a blended learning class.

The results of this study show that social presence significantly influenced student achievement, engagement, and interaction in the station rotation classroom. Findings also suggest that applying social presence to the design of the station rotation classroom is an effective strategy for building a learning community.
Cognitive Presence

Cognitive presence improves the students' perception of learning in a station rotation strategy, promoting participation and critical thinking. The findings showed a statistically significant difference in the posttest mean score from the ANCOVA test comparing the intervention and comparison groups. This difference indicated that students in a station rotation strategy have a more positive perception of cognitive presence than students in a traditional face-to-face instruction mathematics course. This finding is supported by various past studies, including Akyol and Garrison (2011), Akyol et al. (2011), Breivik (2016), Darabi et al. (2011), Kovanović et al. (2016), and Zhang (2020), which pointed out that cognitive presence development can make significant improvements to students’ performance and motivation in the blended learning environment. The results also showed that cognitive presence helped the instructors to identify the skills needed by students in the learning process through triggering an event, exploration, integration, and resolution. This finding is supported by various earlier studies such as Akyol et al. (2009), Beckmann and Weber (2016), McKerlich et al. (2011), Nagy and Mohammed (2018), Shea and Bidjerano (2009), and Wang and Chen (2008), which highlighted that a learner's strengths and weaknesses can be identified in a collaborative activity.

Additionally, the current findings showed that students’ participation, learning outcomes, and engagement in the station rotation classroom increased more than those of students in a face-to-face instruction classroom. This finding is supported by various earlier studies, such as Edwards and Rule (2013), McCollum (2019), Nisa, (2018), Nolan-Grant (2019), Okaz (2015), and Tempelaar et al. (2012), which indicated that combining teaching presence and cognitive presence to design the blended learning environment increased student engagement and
performance. Another finding from the current study is that cognitive presence helped the instructors to provide different instruction in the classroom to meet students’ learning style needs, which enabled students to improve their math skills and make decisions about their learning process. This finding is consistent with research studies conducted by Fazal and Bryant (2019), Kozan and Richardson (2014), Smyth et al. (2012), and Zhang (2020), in which they found that blended learning provides guidance for the development and improvement of teaching instruction in the classroom.

Therefore, applying CoI cognitive presence to design station rotation classroom instruction may help mathematics instructors to improve students’ academic achievement and engagement in a mathematics course in the KSA.

Implications

The findings in this study suggest that sixth-grade students in Saudi Arabia can achieve better performance in mathematics if a station rotation strategy is employed in lesson delivery. In addition, the findings suggest that adopting a station rotation strategy may help to improve learning outcomes and attitudes towards learning among students. A station rotation strategy could help eliminate common limitations associated with the traditional face-to-face style of teaching and learning, such as a greater focus on mathematical rules and memorization, limited chances for the learners to engage teachers and each other more closely, and little room to practice the learned concepts. Furthermore, the station rotation strategy enables the incorporation of education presence (teaching, social, and cognitive presence) in the teaching and learning process. The present study’s findings demonstrate that the positive impact of teaching, social, and cognitive presence on students in a station rotation strategy led to better performance and
attitudes towards learning compared to students in a traditional face-to-face classroom. Therefore, the current findings have various implications for sixth-grade mathematics teachers, curriculum designers, and researchers in the field of pedagogy in Saudi Arabia.

First, this research provides empirical evidence and may help to familiarize teachers in Saudi Arabian schools with the benefits of a station rotation strategy, which is one of the modern and productive teaching models in elementary schools (Kazakoff et al., 2018). The station rotation strategy introduces and promotes varied learning modalities in the classroom setting that enable students to engage in multiple rotation-based learning activities. Leveraging the station rotation strategy in the classroom, teachers can improve students' learning outcomes and motivation to learn complex mathematical concepts. Additionally, using the station rotation strategy, teachers can help the students become more interactive in discussions, promoting the sharing of knowledge and social interaction, and improving cohesion in the learning process. Finally, the station rotation strategy can help teachers identify individual students' strengths and weaknesses during the learning process and devise ways to help them address learning challenges (Shea & Bidjerano, 2009; Wang & Chen, 2008).

Second, this research provides mathematics curriculum developers in Saudi Arabia with insight into the importance of designing the curriculum to suit the station rotation strategy of teaching and learning. Developing a good curriculum should focus not only on the content suitable for sixth-grade students but also on the most effective teaching and learning techniques. Thus, the combination of the three components of the CoI framework and the station rotation strategy provides curriculum developers with an effective approach that can be incorporated in teachers' guides and education policies based on the combination’s positive effects on student performance and motivation to learn mathematics.
Third, this research has various implications for researchers in the field of pedagogy. Researchers in pedagogy seek to investigate various classroom issues and strategies that promote or impede teaching and learning. The current research design focused on teaching and learning mathematics by comparing the face-to-face strategy and the station rotation strategy through empirical analysis of learning outcomes and motivation to learn among students. Therefore, this research contributes new evidence to the existing literature on the impact of teaching presence, social presence, and cognitive presence in teaching and learning. Moreover, the findings in this study could potentially spark fresh interest in investigating the impact of a station rotation strategy on learning other subjects such as language and sciences. Similarly, these findings could motivate researchers to investigate how a station rotation strategy is affected by other classroom factors such as teacher behavior, culture, and learners’ attitudes and beliefs.

Limitations of the Study

The validity of the results of this study may have been affected by some limitations. First, the study was limited to a select group of sixth-grade male Saudi Arabian students within a mathematics classroom. Because the participants were from one city and the sample solely consisted of males, the research does not fully represent the entire KSA education system.

Second, the language barrier impacted the study since the scripts needed translation from Arabic to English. All the students in the intervention group and the comparison group speak Arabic as their first language. Therefore, the adapted survey items from TIMSS and Akyol et al. (2009) were translated into Arabic. Even though this process underwent back translation to review and validate the Arabic-language version, it might not have provided the same perception...
as the original English survey. This process might have affected the meaning of the survey items, hence affecting the response credibility.

Suggestions for Future Research

Future studies should focus on the varying areas that were not explored. For example, this study solely investigated sixth-grade students' achievement within a mathematics classroom; therefore, future research should focus on examining the topic in other grades and other subjects such as sciences. Furthermore, this study utilized the quantitative method; however, the future studies should include different research designs or methods to better understand students' achievement, attitude, and education experience toward learning mathematics. As well, the current study’s sample consisted solely of males. Thus, no main effects or moderating effects of gender on the outcomes were examined. Therefore, future research should include more than a single gender to examine these effects and expand the findings of this study. Finally, this study was conducted in one sixth-grade elementary mathematics class; further research should be conducted in different elementary schools throughout Saudi Arabia.

Chapter Summary

In this study, student performance, attitude, and education presence were analyzed through a blended learning station rotation strategy within a mathematics classroom. The present study utilized the CoI framework as a theoretical framework. It utilized the CoI framework to investigate the effectiveness of station rotation strategies for teaching mathematics to sixth-grade students. The study examined the implementation of the three components of community of inquiry in the station rotation strategy: teaching, social, and cognitive presence.
The findings suggest that station rotation is a valuable strategy to improve students' academic performance within a mathematics classroom. Through an individual examination of each variable, student achievement, attitude, and student presence were found to be significant positive factors for learning mathematics. These findings align with previous research studies that indicate that student achievement, attitude, and education presence are significant when using blended learning to teach mathematics (Hesse, 2017; Wang & Chen, 2010; Waynick, 2015).

Moreover, the findings of the study demonstrated that station rotation strategy showed statistically significant positive effects of the intervention on student achievement, student attitude, and student education presence. Finally, this chapter presented information about the implications of the research, the limitations of this study, and suggestions for future research.
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https://www.learntechlib.org/p/152959/


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APPENDIX A

MATH PRETEST
Multiple Choice: Read and circle the correct answer.

1) What is the next number in the pattern 5, 11, 17, 23, ………?  
   A) 29   B) 30   C) 32   D) 35

2) What is the value in the middle of the data after arranging it in ascending order or descending order called? 
   A) Mediator   B) The vein   C) The Term   D) The average calculation

3) Select the decimal fraction for $\frac{8}{10}$ ……  
   A) 0,98   B) 0,08   C) 0,80   D) 0,89

4) The most common value in the data is called  
   A) Mediator   B) The vein   C) The average calculation   D) Term

5) Which of the following is ordered from least to greatest?  
   A) 0.25, 0.279, 0.28, 0.3   B) 0.3, 0.279, 0.28, 0.25   
   C) 0.3, 0.28, 0.279, 0.25   D) 0.28, 0.279, 0.25, 0.3

6) The total values divided by their number are called  
   A) Mediator   B) The vein   C) The average calculation   D) Term

7) Using the -------- for the comparison of data and arrangement.  
   A) Lines   B) Columns   C) Points   D) Curve.

8) Basil is thinking of three numbers from 1-9. The sum of the numbers is 20. What are the numbers?  
   A) 8,9,3   B) 7,8,5   C) 9,5,6   D) All of the above

9) The value of the equation $5 \times 2 + 10$ is  
   A) 20   B) 60   C) 200   D) 17

10) If A=6, B=4, what is the value of the equation $a + b$?  
    A) 2   B) 24   C) 10   D) 11
11) What is the value of \( n \) in the equation \( n^4 = 16 \)?
A) 2     B) 3     C) 4     D) 8

12) Add: \( 63 + 9 + 37 = \ldots \ldots \).
A) 100     B) 109     C) 110     D) 123

13) What is the number of recurrent occurrences of one species called?
A) Data     B) Graphic diagram     C) Digital offset gap     D) Repetition

14) Write the numbers in words?
A) Verbal order     B) Standard order     C) Analytical order.

15) What is the number 1.75 is rounded to a whole number.
A) 1.75     B) 2     C) 7     D) 5

16) The primary factors of the number 36 are
A) 2, 3     B) 5, 3     C) 6     D) 6, 6

17) \( 7^4 \) is read as….
A) Squared seven     B) Four up to the seventh force
C) Seven to the fourth force     D) The seventh force of number two

18) Evaluate. \( 15 - 2^3 / 4 = \)
A) 13     B) 15     C) 4/7     D) 4/9

19) The initial number of the following number is
A) 6     B) 8     C) 2     D) 4

20) Add. \( 5.5 + 3.2 = \)
A) 7.8     B) 8.7     C) 15     D) 35.52
APPENDIX B

MATH POSTTEST
Multiple Choice: Read and circle the correct answer.

1) What is the missing number in the pattern ……, 33, 41, 49, 57?
   A) 25       B) 26         C) 24        D) 20

2) The arithmetic means of value 5, 7, 3, 4, 11 is
   A)7       B) 5         C) 3        D) 11

3) The decimal fraction for 0.800 is
   A) 0.98   B) 0.08     C) 0.8    D) 0.89

4) The vein for the following values 2,4,5,4,7,7,4 is
   A) 7       B) 4        C) 5       D) 2

5) The smallest among Decimal Fractions 0,25 ‘0,279 ‘0,28 ‘0,3 is
   A) 0,3      B) 0,28     C) 0,279

6) The following graphic diagram represent the number of the hours spend my
   Mohammed
   and his friends in the sport center for one week is.

Which the following sentences are true to the data in the diagram?

A. Mohammed spend three times more than Fahad did
B. Saad spend almost 15 hours
C. Mohammed spends the most time than others
D. Khaled spend twice the times spend by Fahad

7) The following diagram represents the amount of money with 20 students.
How many students have $9?

![Diagram]

A) 3 Students    B) 6 Students    C) 4 Students    D) 2 Students

8) The sum of the two numbers equal to 11, and the sum of multiplication is equal 30, what are the two numbers?
A) 2,9    B) 10,3    C) 5,6    D) all the above

9) The equation value 15-2 x (5+26) =
A) 47    B) 60    C) 21    D) 17

10) If A=21, B= 10 then the value of the equation A-B is
A) 31    B) 210    C) 10    D) 11

11) The true answer of the equation 4+N +16 is
A) 20    B) 12    C) 4    D) 8

12) What is the value of 2X +3, if X=3?
A) 9    B) 8    C) 12    D) 3

13) The number of repetition or occurrence of the one species is called
A) Data    B) Digital representation    C) Digital offset    D) Repetition

14) The sum of the outputs multiplies by all its values each one in its stature is
A) Verbal order    B) Standard order    C) Analytical order
15) When the number 5.01 rounded to the total number becomes
A) 1.05   B) 4   C) 6   D) 5

16) The primary factors of number 24 are
A) 3, 2   B) 5, 3   C) 4, 6   D) 2, 12

17) $7^4$ is read as….
A) Squared seven   B) Four up to the seventh force
C) Seven to the fourth force   D) The seventh force of number two

18) the base function represented in the corresponding table is?

<table>
<thead>
<tr>
<th>x</th>
<th>0</th>
<th>20</th>
<th>35</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>4</td>
<td>7</td>
</tr>
</tbody>
</table>

A) $2x - 2$   B) $4x$   C) $5x$   D) $x + 16$

19) The non-initial number of the following number is
A) 6   B) 5   C) 3   D) 2

20) $5.5 - 3.2 =$
A) 7.8   B) 8.7   C) 2.3   D) 35.52
APPENDIX C

STUDENT QUESTIONNAIRE
Thank you for helping me learn more about the station rotation strategy in your classroom. Your answers will help other teachers know more about blended learning, too. Here are a couple of things you should know before you begin:

- There are no right or wrong answers to these questions, just your opinion.
- Please be honest and share both the good and the not so good things that you notice in your classroom.
- If you do not understand what a question is asking you, please raise your hand, and I can explain it to you.
- Please write neatly and in complete sentences, so I can understand your answers.

Let’s get started!
## Part One

<table>
<thead>
<tr>
<th>Construct</th>
<th>Agree a lot</th>
<th>Agree a little</th>
<th>Disagree a little</th>
<th>Disagree A lot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Like learning Mathematics (LLM)</td>
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<tr>
<td>1 I enjoy learning mathematics.</td>
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<td>2 I wish did not have to study mathematics*</td>
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<td>3 Mathematics is boring*</td>
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<td>4 I learn many interesting things in mathematics.</td>
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<td>5 I like mathematics</td>
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<td>6 I like any coursework that involves numbers.</td>
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<td>7 I like to solve mathematics problems</td>
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<td>8 I look forward to mathematics lessons.</td>
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<td>9 Mathematics is one of my favorite subjects.</td>
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<td>Confidence to learning Mathematics (CLM)</td>
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<td>10 I usually do well in mathematics.</td>
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<td>11 Mathematics is harder for me than for many of my classmates*</td>
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<td>12 I am just not good at mathematics*</td>
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<td>13 I learn things quickly in mathematics</td>
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<td>14 Mathematics makes me nervous*</td>
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<td>15 I am good at working out difficult mathematics problems</td>
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<td>16 My teacher tells me I am good at mathematics</td>
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<td>17 Mathematics is harder for me than any other subject*</td>
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<tr>
<td>18 Mathematics makes me confused*</td>
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<tr>
<td>Construct</td>
<td>Strongly Agree</td>
<td>Agree</td>
<td>Neutral</td>
<td>Disagree</td>
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<td>Teaching Presence (TP)</td>
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<tr>
<td>19 The teacher clearly explained important lesson goals.</td>
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<td>20 The teacher provided clear instruction on how to participate in class learning activities.</td>
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<td>21 The teacher designed assessments that are connected with learning goals.</td>
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<td>22 The teacher clearly communicated important due dates/time frames for learning activities.</td>
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<tr>
<td>23 The teacher kept students engaged.</td>
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<td>24 The teacher kept students on task in a way that helped me to learn.</td>
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<td>25 The teacher encouraged students to explore new concepts in this course.</td>
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<td>26 The teacher helped to focus activities on related learning lesson goals in a way that helped me to learn.</td>
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<td>27 The teacher provided feedback that helped me understand my strengths and weaknesses related to the course’s goals and objectives.</td>
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<td>28 The teacher provided feedback in a timely fashion.</td>
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<td>Social Presence (SP)</td>
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<td>29 I felt comfortable interacting with other course participants.</td>
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<tr>
<td>30 I felt comfortable participating in the course activities.</td>
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<tr>
<td>31 I felt the teaching strategy help me to develop a sense of collaboration.</td>
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<tr>
<td>Cognitive Presence (CP)</td>
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<tr>
<td>32 Learning activities increased my interest in this mathematics course.</td>
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<tr>
<td>33 Course activities increased my curiosity</td>
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<tr>
<td>34 I used a variety of information sources to explore problems posed in this mathematics class.</td>
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<tr>
<td>35 Learning activities helped me understand fundamental concepts in this class.</td>
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<tr>
<td>36 Teaching strategy helped me answer questions raised in course activities.</td>
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</tbody>
</table>
Part Three

1. What do you like the most about station rotation strategy? Why?

                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           

2. What do you like the least about station rotation strategy? Why?

                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           

3. Do you feel like you learn more or less during station rotation strategy than you do during the regular class time? Why?

                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           

APPENDIX D

PERMISSION FORM FOR PARENTS/GUARDIANS OF MINORS
Your child is invited to participate in a research study titled *(Using Community of Inquiry to Examine The effect Of Station Rotation Strategy in Elementary Mathematics)* being conducted by Ahmad Alshahrani, a graduate student at Northern Illinois University.

**Key Information**

- This is a voluntary research study on *to examine the effect of using a station rotation strategy to improve students’ achievement, attitude and educational presence toward learning mathematics among six grade students in the Kingdom of Saudi Arabia (KSA).*
- This eight-week study involves *complete achievement test a questionnaire.*
- The benefits include *exploring a new method for learning mathematics,* and there are no foreseeable risks in participating in this study.

The purpose of this study is to examine the effect of using a station rotation strategy to improve students’ achievement, attitude and educational presence toward learning mathematics among six grade students in the Kingdom of Saudi Arabia (KSA). Your child’s participation in this study will last eight weeks. He will be asked to complete achievement test a questionnaire about his attitude and educational presence toward learning mathematics.

The benefit your child may personally receive from participating in this study is exploring a new method for learning mathematics that combines small group instruction, independent and collaborative practices, and using technology.

The records of this study will be kept strictly confidential. Research records will be kept in a locked file, and all electronic information will be coded and secured using a password protected file.

Information obtained during this study may be published in scientific journals or presented at scientific meetings, but that any information that could identify your child/ward will be kept strictly confidential. Your child/ward information collected as a part of this research will not be used or distributed for future research, even if all identifiers are removed.

Participation in this study is voluntary. Your decision whether to allow your child as well as his assent to participate will not negatively affect you or your child. Your child will be asked to indicate individual assent to be involved immediately prior to participation and will be free to withdraw from participation at any time without penalty or prejudice.

Any questions about the study should be addressed to:

**Researcher:**
Ahmad Alshahrani
Cell phone: [redacted]
Email: [redacted]

**Researcher advisor:**
Dr. Hayley Mayall: [redacted]
Phone: [redacted]

If you wish further information regarding your rights or your child’s rights as a research subject, you may contact the Office of Research Compliance at Northern Illinois University at (815) 753-8588.

I agree to allow my child to participate in this research study and acknowledge that I have received a copy of this consent form.

__________________________________________
Signature of Parent/Guardian                      Date
APPENDIX E

PERMISSION LETTER
To the of Director of General of Education in Bisha,

My name is Ahmad Alshahrani; I am a doctoral candidate in the Department of Education Technology, Research and Assessment at Northern Illinois University. I am conducting a study entitled *Using Community of Inquiry (CoI) to Examine the Effect of Station Rotation Strategy in Elementary Mathematics*.

The purpose of this quantitative study is to examine the effect of using a station rotation strategy to improve students’ achievement, attitude and educational presence toward learning mathematics among six grade students in the Kingdom of Saudi Arabia. This research project is a partial fulfillment of the requirement for a Ph.D. in Instructional Technology at Northern Illinois University. So, I am asking you to give me a permission to conduct this study.

Sincerely,

Researcher: Ahmad Alshahrani
Doctoral Candidate
Northern Illinois University
APPENDIX F

ASSENT FORM—STUDENTS
Dear Sixth Grader,

I am a student at Northern Illinois University, and I am doing research on blended learning in your classroom. That means I am studying how to implement blended learning and what you think of it. I will be sharing what I learn with teachers who want to do blended learning, too. I would like to ask all the sixth grader to be a part of my study. If you want, you can be one of those students, too.

If you are a part of my study, you will answer questions on paper that tell me what you think about the learning strategy which was used in the classroom. There are no right, or wrong answers and your answers will not be graded. Being a part of this study will not hurt you. Your parents have said it is okay for you to participate in my study, but you do not have to. It is up to you. Also, if you say “Yes” but then change your mind, you can stop any time you want to.

Do you have any questions for me about my research? If you want to be in my research and share your thought about the learning strategy which was used in the classroom, please sign your name below and write today’s date next to it. Thanks!

..............................................................................................................  .................................................................
Student                                                                 Date

..............................................................................................................  .................................................................
Researcher                                                               Date
Asking the Col framework items permission

Ahmad,
You have my permission to use the Col survey and figures associated with the Col framework.
Best wishes,
DGR

Sent from my iPad

---

You forwarded this message on Wed 5/15/2019 4:40 PM

Ahmad Alshahrani
Fri 5/17/2019 6:17 PM
gmam@ucalgary.ca

Hi D.Garton,

My name is Ahmad Alshahrani and I wish to inform that I am a Research Scholar in the Department of Instructional Technology, Northern Illinois University under the supervision of Dr. Hayley Mazdi, Associate Professor, Department of Instructional Technology and my research topic is "Investigated the effects of a station rotation blended learning strategy for teaching math on students’ achievement, attitude and education experience toward learning math among sixth grade students in Kingdom of Saudi Arabia (KSA)."

In this regard, I am conducting surveys for data collection among male elementary sixth grade students in the KSA. The main objective of this study is to helping the elementary school teacher in the KSA to use Col elements to design the station rotation blended learning classroom environment.

Therefore, may I request you to kindly grant permission to use surveys items among sixth grade students in the KSA, community of inquiry model, and practical inquiry figures as well. Information provided by the students will be kept confidential and used for academic purpose only.

Thanking you and with warm regards.

My sincerely,

Asking a permission for mathematics survey items 2015 for forth grade

Secretariat IEA <secretariat@iea.nl>

Mon 4/8/2019 10:26 PM

Ahmad Alshahrani

Dear Ahmad,

We have assess your request and are glad to inform you that we grant you permission to use the requested materials in the way you described in the form. Please assure that you only use the requested material accordingly to our conditions. This includes the correct use of IEA references and a non-distribution to third parties.
The reference of your request is IEA-19-032.

Here attached is the form duly signed in return. You can find the international version of the student questionnaire here:
https://mmssanddolls.br.orb/mmss2015/questionnaires/index.html

Kind Regards,

Sandra Dohr, MA
Junior Research Officer

IEA
Researching education, improving learning
International Association for the Evaluation of Educational Achievement