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The Effects of an Evidence-Based Instructional Program on Science Teaching to Students with Special Needs in Inclusive Classrooms

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Abstract: The current study aimed to investigate the impact of an evidence-based instructional program consisting of: Explicit Instruction (EI) along with Numbered Heads Together (NHT) in comparison to the traditional, hand raising (HR) technique on fourth-grade students with and without special needs' daily science quiz scores. Additionally, the researchers sought to explore the impact of the interventional program on the cumulative, pre and post-test performances of participants. Using mixed methods—single-subject, alternating treatment (comparing the interventional program [EI & NHT] to HR), and quasi-experimental designs—data were collected. Data were analyzed using a measure of central tendency (mean scores) of daily science quiz scores, and t-tests to derive results from the pre and post-test cumulative scores. The findings revealed all students in the experimental group, including those with special needs, improved their mean scores on daily science quizzes, along with cumulative, post-test performances. This improvement was achieved after the delivery of the interventional program. Social validity interview with the classroom teacher demonstrated that the instructional program provided a motivational, engaging learning atmosphere for all students including those with special needs. Recommendations for future research and practices were provided.

Keywords: inclusive class, Numbered Heads Together (NHT), science, disabilities

أثر البرنامج التعليمي المبني على الأدلة في تدريس العلوم للطلاب ذوي الاحتياجات الخاصة في الفصول الشاملة

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الملخص: تهدف هذه الدراسة إلى استقصاء تأثير البرنامج التعليمي المبني على الأدلة الذي يشتمل على إستراتيجيَّة الرؤوس المرقمة [EI] Explicit Instruction متزامنة مع التدريس الواضح، ثم مقارنة فَعاليَّة هذا البرنامج [NHT] Numbered Heads Together بالطريقة التقليدية المتمثلة برفع اليد [HR] Hand Raising على أداء طلاب الصف الرابع الابتدائي في الاختبارات القصيرة اليوميَّة لمادة العلوم. كما تسعى الدراسة إضافة إلى ذلك لاستكشاف انعكاس البرنامج التدخُّلي على الأداء التراكمي للمشاركين في الاختبارات السابقة واللاحقة. وقد جُمعت البيانات اللازمة لهذه الدراسة باستخدام منهجياتٍ بحثيَّة متعددة، تضمَّنت تصميم الحالة الواحدة (والعلاج بالتناوب / متعدد التدخُّلات)، والتصميم شبه التجريبي؛ وذلك لمقارنة فَعاليَّة البرنامج التدخُّلي (التعليمات الصريحة / التدريس الواضح وإستراتيجية الرؤوس المُرقَّمة) EI & NHT مع الطريقة التقليدية (رفع الأيدي) على نتائج اختبارات العلوم اليومية. جرى تحليل البيانات باستخدام أحد مقاييس النزعة المركزية HR (المتوسطات الحسابية)، واختبار للاختبارات التراكمية السابقة واللاحقة لاستخلاص النتائج من الدرجات التراكميَّة للاختبارات السابقة واللاحقة t-tests.واختبار ت وأظهرت نتائج الدراسة أنَّ جميع الطلاب في المجموعة التجريبيَّة، بما في ذلك الطلاب ذوي الاحتياجات الخاصة، قد حققوا تحسُّنًا في متوسطاتهم في اختبارات العلوم اليوميَّة، إضافةً إلى تحسُّنِ الأداء التراكمي في الاختبارات اللاحقة، وذلك بعد تطبيق البرنامج التدخُّلي . كما كشفَت المقابلة مع المعلمة حول الصلاحية الاجتماعية (Social Validity)/ الصدق الاجتماعي أنَّ البرنامج التعليمي قدَّم بيئةً تعليمية تحفيزيَّةً وجاذبة لجميع الطلاب، بما في ذلك الطلاب ذوي الاحتياجات الخاصة. واختُتمَت الدراسة بتقديم جملةٍ من التوصيات للبحوث المستقبليَّة، والتطبيقات العمليَّة.

الكلمات المفتاحية: الفصل الشامل / المدمج، إستراتيجيَّة الرؤوس المُرقَّمة (NHT)، العلوم، الإعاقات

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Introduction

One of the international declarations that has shaped the provision of educational services, integrating a broader concept of inclusion into all education systems, is The Salamanca Statement, released in Salamanca, Spain, in 1994 (Ainscow et al., 2019). The declaration, as expressed in the Salamanca Statement and Framework, clearly endorsed the concept of the inclusion of individuals with disabilities (National Center for Educational Development [NCED] & Ministry of Education [MoE], 2018). Specifically, the statement affirms that individuals with disabilities have the right to access inclusive education, coincident with their typically developing peers, in order to fulfill their learning/educational needs without discrimination (Wibowo & Muin, 2018). Given that "there has been an increasing concern among teachers about universalizing inclusive education" (Kamran et al., 2023, p. 2), not surprisingly, national and international laws and legislation demand the inclusion of individuals with disabilities in all fields of society, including education. The Individuals with Disabilities Education Improvement Act (IDEIA) of 2004, along with the No Child Left Behind Act (2001), emphasized the notion of the inclusion of all students, with and without disabilities, in general education environments to prepare them for successful future engagement in their communities (Bryant et al., 2020; Grenier et al., 2023). Additionally, the United Nations' Convention on the Rights of Persons with Disabilities (CRPD, 2016) asserted that students with disabilities should be provided with access to general education curricula and instruction, fulfilling their diverse learning needs. It also expressed that these individuals have human rights related to gaining a basic education, on an equal basis as their peers without disabilities (CRPD, 2016).

According to Pierangelo and Giuliani (2012), American federal education policies have served as legal and legislative models for other countries in the area of inclusion and special education service delivery. Nationally, the development of special education services and preparedness to include individuals with disabilities were highly influenced by these international laws. The Kuwaiti educational system, for example, took a massive step forward to involve students with disabilities in its general education classes (NCED & MoE, 2018). Specifically, in Law No. 8 (2010), Article 9 states:

The Kuwaiti government is mandated to provide the educational services and facilities for individuals with disabilities in equity with others without disabilities, fulfilling the individuals with disabilities' special needs in communication, language and training. Along with the adequate preparation of education staff of teachers, professionals, and leaders and with high-levels of quality and professionality to better educate students with special needs.

Of note, there is a critical need to instruct students with and without disabilities using high levels of quality and professionalism. Providing adequate, inclusive learning opportunities through the use of evidence-based instructional strategies would maximize all students' learning (Grenier et al., 2023), including those with disabilities and at risk of school failure. Many students at risk of school failure and/or with disabilities might perform in an "abysmal" manner (Fuchs et al., 2018, p. 127) with regard to academics in inclusive classrooms. In fact, they might perform far below their actual grade level (Gilmour et al., 2018) in different subject areas, including reading, writing, and mathematics. The effective engagement of students with disabilities and at risk of school failure in inclusive classrooms, where general education curricula are being implemented, accelerates their acquisition of needed learning skills, thus preparing them for life's demands (Westling et al., 2015). Wilhelmsen and Sorensen (2017) added that teachers' preparation and experiences positively affect their students with disabilities' acquisition of the learned content (academic, functional, social, and life skills). Thus, teachers' educational knowledge and praxis often facilitate the educational practices within an inclusive educational setting for students with disabilities (Timberlake, 2014; Giese & Ruin, 2018). In this regard, research-based (or evidence-based) instructional strategies have emerged in the field to support all students' educational experiences and to enhance the instructional practices that are employed (Olson et al., 2016).

Science Instruction

According to Knight et al. (2020), all students have the right to obtain access to educational knowledge in different learning strands, including science. Spooner et al. (2011) explained that students with and without disabilities are required to gain scientific knowledge through scientific literacy practices and authentic inquiry opportunities. Jasim (2002) highlighted the importance of teaching science to all students, in all grades/levels. Osborne (2014) indicated that learning science leverages students' abilities in asking questions and analyzing themes. Such interaction would evolve their knowledge of nature and the environment, as they communicate these concepts and information and use them in multiple school and life contexts/situations. Knight et al. (2020) added that when students learn about the natural world, this provides them with opportunities to develop new interests and gain scientific concepts about their environment, shaping their learning experiences which in turn support their post-school lives. Science learning involves understanding the science of nature, constructing core concepts, natural phenomena investigation and problem solving, and scientific, school-based experiences (Jasim, 2002). Jasim (2004) added that science instruction develops students' thinking and problem-solving skills, which represent one of the highly crucial goals of science education. Berk (1992) indicated that the main goal of science content instruction is to illuminate students' scientific literacies and improve their science practices. The National Research Council (NRC, 2012) defined science practice as basically scientists' habits and skills. The Next Generation Science Standards (NGSS, 2013) emphasized the need to teach science practices in order to accelerate students' levels in science and improve their learning outcomes. Moreover, using effective strategies in the instruction of science enhances students' abilities to deal with real-life situations in the future, which is especially true for those with disabilities (Knight et al., 2020). Miller et al. (2015) added that the effective instruction of science to all students, especially those with exceptionalities, helps them to acquire scientific knowledge/experience and then generalize and apply it in varied contexts (e.g., students with disabilities could apply what they learn about the weather conditions in Kuwait). One of the salient instructional practices by which science education could be effectively delivered to students with and without disabilities is the cooperative learning approach. Another effective teaching strategy that was proved in prior literature to teach several subject areas including science is explicit instruction (EI).

Explicit instruction (EI) is an evidence-based instructional strategy that delivers learning content in a straightforward, clear method for students. Rosenshine (1987) explained EI as a systematic instructional strategy which emphasizes the proceeding in a learned skill in small steps, checking understanding of students. It also helps them accomplish active and successful class contribution. According to Archer and Hughes (2011), explicit instruction is a systematic, direct, engaging and success-oriented teaching strategy. Fletcher et al. (2019) stated in EI, students are taught what they need to do by having direct instructions and explanations along with sharing and modeling the new knowledge. Prior research has demonstrated that EI promotes academic achievements, raising the successful learning outcomes for all students including those with special needs (Hughes, et al., 2017). Hughes et al. (2022) highlighted the notion EI is a practical and accessible resource of instruction. EI provides clear and organized teaching of learned skills to students in both special and general education settings. When EI is in use, teachers are being led to teach with clear guidelines, identifying key concepts, strategies, skills, and routines for teaching (Hughes et al., 2022).

As previously indicated by Archer and Hughes (2011), EI involves sixteen elements which help students to walk through the learned skill from accuracy reaching to mastery level. Elements of EI involve: Clarity, sequence logic, core content concentration/focus, review of prior skill before the introduction of new skill, breaking the complex skill into smaller units, concision, precision and providing immediate, affirmative, and corrective feedback (Archer & Hughes, 2011). In essence, reduction of cognitive load means how to break down big steps/procedures of a complicated skill to smaller units so that the students could absorb these small units more accurately, without distraction (Alan & Erdogan, 2018; McManus, 2023). After reaching the mastery level of each smaller unit, when needed, students would be able to put all these units together and use them as a whole (i.e., learning addition, subtraction, and multiplication in different mathematics classes then using them for long division lesson). The idea of affirmative feedback in EI, on the other hand, is pertained to the notion of showing agreement and/or disagreement to the student's response (Archer & Hughes, 2011). This type of feedback would display the correct from the false information a student might gain while learning. If a concept was understood correctly by the student, she/he would preserve it, if not, the student (with the help of the affirmative feedback) would simply modify her/his repertoire and correct it. These elements facilitate the process of learning the new content for all students especially those with special needs (Spit, et al., 2022).

Several studies investigated the impact of EI on students' academic achievement. Mustafa and Sharab (2010) explored the effects of EI on the writing performance of students with special needs (dysgraphia) in writing in their second language, English. Using quantitative, experimental design, 62 (male and female) students in 3rd grade participated in the study. Results indicated participants increased their mean scores after receiving EI instructional program. In a study of Khishfe (2021), EI was explored on argumentation skills in science class of 36 participants, enrolled in grade 10. Using pre and post-tests, quantitative methodology, findings demonstrated that participants (who received EI) showed improvements in their argumentation skills. The researcher utilized semi-structured interviews to deduce more detailed results. Outcomes indicated students' preference to EI because it provided them with direct, step by step knowledge on how to argument their scientific ideas and thoughts.

Granado-Peinado et al. (2023) investigated both the strategy of EI and collaborative, pair work for teaching argumentative synthesis writing. The authors developed a writing program consisted of EI procedures and pair, collaborative work in which high and struggling writers would help and work together to produce their argumentative, written, synthesized pieces. Using quantitative, ANOVA analyses of written products of 112 participants, results showed that participants in experimental group improved the quality of their syntheses in two dimensions: argument identification and analysis. These participants exceeded their performance after the introduction of the interventional program (EI and collaborative work: practicing in pairs). The interventional program led to positive effects on argument identification, however for argument integration increase was solely due to EI component. Tobbi (2023) sought the effects of EI in comparison to implicit instruction on the production complaints in English as a Foreign Language (EFL) of Algerian, learners. Forty, Junior, English major students participated in the study. Using quantitative, pre and post-tests, results indicated that experimental group (who received EI) significantly improved their EFL achievement in their post tests.

Many students with and without disabilities encounter learning challenges during the course of their school education. These problems, as manifested by students, might involve (but are not limited to) a misunderstanding/misconception of the learning content presented to them, an unattractive learning environment, and a failure to fulfill the requirement(s) of success in a subject area. This brings to our attention that students with mild to moderate learning disabilities do not usually fare as well in school as their typically developing peers (Haydon et al., 2010; Lerner & Johns, 2009). Students with learning problems tend to display low academic performance due to multiple factors such as high rates of absenteeism and low grades, and eventually they will be at risk of failure in several subject areas. These factors—and others—may lead to below-grade-level performance, extending the length of their school years to a greater degree than would be expected (Al-Habeeb, 2018; Ryan et al., 2004).

It is highly crucial to seek instructional strategies that are evidence-based and helpful in delivering content in greater depth. Al-Habeeb (2018) stated when students actively learn, their gain of such learning goes beyond facts and knowledge. Jasim (2004) highlighted the need to adapt techniques of "active learning" (p. 35), which is directly connected to the evidence-based practice of cooperative learning. Strategies of cooperative learning depend on the notion of engaging students in the process of learning, specifically through collaborating and/or cooperating with their peers (Al-Aga, 2023). Both Johnson and Johnson (1994) and Johnson et al. (1998) previously described cooperative learning strategies as consisting of four components: a) positive interdependence (i.e., there should be common goal/reward structure system), b) individual accountability (i.e., each student is responsible for their own learning, demonstrating collaborative work), c) face-to-face positive interaction while engaged in group work, and d) equal opportunities to respond for all students. Hattie (2009) added that group cooperation is more highly effective than individualistic effort. Other educators have noted that tangible incentives noticeably improve students' learning outcomes and engagement (Almumen et al., 2023; Maheady et al., 2006). A well-acknowledged group cooperation learning strategy, manifesting significant effects on students' learning and engagement in class activities, is Numbered Heads Together (NHT). NHT is one of over 100 cooperative learning strategies developed and presented by Spencer Kagan and associates (Kagan & Kagan, 2009). According to Al-Aga (2023), NHT relies on the idea of collaboration among students in one single group, in which each student is responsible for what he has learned as well as for the learning of his classmates in the group. Such cooperation creates the spirit of group work, offering help and assistance among the classmates and resulting in positive, targeted learning outcomes (i.e., on-task behaviors, active academic engagement) (Arends, 2004; Maheady et al., 1991). In NHT, the academic performance is effectively intervened, helping students reach the mastery levels of the academic skills (McMillen et al., 2016). This strategy works in a highly efficient manner to encourage students to participate in learning contexts, in an equilibrium with raising their academic performance and the rate of successful learning outcomes (Wora et al., 2017). It also represents a promising instructional tool because it involves peers mediating the instructional process, introducing the learning content in a simpler way than teachers usually do (Maheady et al., 2006). Students would be provided with opportunities to share their ideas/answers, giving immediate, corrective feedback to their classmates who need it and monitoring their classmates' performances, all while progressing toward the mastery of a learned skill (Haydon et al., 2010).

Prior research revealed the key goal of NHT as basically giving students the opportunity to lead the learning process and respect their classmates' opinions/perspectives regarding information, resulting in high instruction-related outcomes (Baker, 2013; Sa'ada, et al., 2008). Eltaieb (2019) sought the impact of NHT on the development of measurement concepts among children with intellectual disability. Twenty-four, aged 9-12 children with intellectual disability participated in the study. Using semi-experimental, control and experimental group design, results showed there were statistically significant differences between the mean scores of performances of experimental group children. These improvements in in acquiring mathematical concepts were gained after the delivery of the NHT strategy. NHT motivates students to engage in more teamwork (Haydon et al., 2019; Leasa & Corebima, 2017), wherein active learning is apparent. In active learning, "students usually work in teams for extended periods of time with collective objectives to accomplish" (Jasim, 2004, p. 35). Jasim (2004) added that active learning is represented in several forms of student-centered learning, including analysis, problem-solving, and discovery, along with creative activities. Students are responsible for processing data and/or information while working in class in order to come up with their own conclusions (Germann, 1991).

Therefore, the purpose of the current study is to investigate the impact of EI and NHT (without incentives) on the science performance of fourth grade students in inclusive classes. More specifically, the present exploration compared the effects of EI and NHT without incentives to hand raising (HR) on fourth graders' performance on science quizzes and cumulative assessment (pre- and post-tests) and assessed the social acceptability of EI and NHT via structured teacher interview. To fulfill this purpose, the following research questions were posed:

1) What is the impact of EI & NHT (without incentives) on the number of correct answers per daily science quizzes of the participants?
2) Are there any statistical differences between control and experimental groups in the learning outcomes and acquisition of the content?
3) Is there any statistical difference between the control and experimental groups' pre- and post-tests?
4) What is the effect degree (i.e., effect size) of the experimental group performance and after the delivery of the intervention?
5) From a social validity standpoint, how did science classroom teacher perceive EI & NHT in learning scientific concepts/themes?

Research's Terms

Main study's terms are defined procedurally as the following:

Explicit instruction (EI): is an evidence-based instructional strategy that breaks down complicated skills into small units with precise and concise way of delivering the content. It involves step-by-step modeling of the instruction.

Numbered Heads Together (NHT): is a cooperative learning strategy, in which students are put in group so they collaboratively work as a team. The responses of students depend on consensus among the team members.

Inclusive class: learning environment where all students with and without special needs have the access to the General Education learning curriculum with certain modification and/or accommodations required for students with special needs, using evidence-based instructional strategies to deliver learning content.

Methodology

Research Design

Mixed methods (single-subject and quasi-experimental) were used to explore the impact of EI and NHT on the acquisition of the science knowledge and concepts of fourth grade students, with and without special needs, studying in a general education (inclusive) class. A pre-experimental, single-subject research, alternating treatment design was used to compare student performances under the conditions of HR and EI with NHT (without incentives). This pre-experimental design was used to provide important descriptive and correlation information on both dependent and independent variables' relationships in the context of the study (Kazdin, 2011). Quasi-experimental design (control and experimental groups, pre- and post-tests) was also used before and after the implementation of EI and NHT to derive inferences on participants' science performances.

Participants and setting

This study took place in a public, general education school located in Farwaniya School District, Kuwait. A convenience sample consisting of 40 fourth grade students, ages 9–10 years and all speakers of Arabic, was used for this research. Twenty students were assigned to each group (experimental and control). Students with special needs were also assigned equally to each group. Each group involved, along with typically developing students, the following cases: one student with a learning disability and two students with disruptive behaviors and/or who were at risk of school failure in various subject areas, including science. These students were randomly distributed to each group.

The distribution of the participants into two groups (control and experimental) was depended on the results of the pre-tests of participants. The pre-test is usually conducted to verify the quality of the experimental and control groups, along with measuring the improvement of the experimental group. Table 1 depicts the pre-test results of participants in two groups.

Table 1: T-Test for the pre-tests of Control and Experimental Groups

Measure	Group	N	Mean	Standard Deviation	T-Value	Statistical Significance P values
Pre-test	Experimental	20	5.30	1.809	0.717	0.478
	Control	20	5.70	1.719		

Once school district permission was obtained, the district's superintendent selected an elementary, general education school for girls to participate in the study. Participants were recruited upon securing the required institutional approvals. The assistant principal used student school records and science teacher recommendations to recruit the students. Parents/legal guardians' permission was also sought, after which the authors directly commenced their research investigation. Several ethical considerations were tackled prior the commencement of the research phases and while recruiting the students. These considerations involved: preserving students' data/quizzes/pre and post-tests. All students' personal data (i.e., name, chronological age, level performance, quiz and test results) were kept in a case with the first researcher, all the time, putting numbers to each student to keep her as an alias/anonymous and preserving the students' confidentialities. Students' data would be determinate when they were no longer needed.

The classroom teacher was a Caucasian female, with 13 years of teaching experience in inclusive classes in the general education school. She earned her bachelor's degree in science education. At the time of the study, she was teaching two classes: fourth grade, and one class of fifth grade. The research exploration took place in two classes of fourth grade, in which some students exhibited chronic academic as well as behavioral problems. Science classes in public schools are usually conducted in the schools' science laboratories.

All sessions of the research phases were held during 45-minute, regularly scheduled science classes. The students in both groups (control and experimental) were seated on science laboratory benches (four students on each bench), forming two rows (each row consisting of two benches). The teacher stood at the front of the laboratory. The laboratory comprised numerous types of science equipment, which were on the benches and on the shelves behind the students; these included microscopes, test tubes, flasks, thermometers, droppers, magnets, spring balances, funnels, and the like. At the back of the laboratory, there was a small cubby in which students' classwork folders (workbooks and sheets) were placed, and another cubby containing tags with student names for hanging lab coats at the end of class prior to returning to their homeroom. For the intervention phase, along with experimental design and research procedures (of the experimental group), the students were instructed in the same laboratory but seated in heterogenous groups (i.e., special needs students were seated with their typically developing peers).

Lesson structure followed a common pattern and was held constant across all study phases. The structure involved a teacher-led review of prior lessons/content, clear statements of daily lesson goals, and explicit instruction (modeling and demonstrations) with extensive use of instructional aids (i.e., picture, charts, and Power Point presentations, along with the abovementioned laboratory equipment).

Dependent variables

Two dependent variables were investigated in the context of the study: a) the number of correct answers on five-item science quizzes, administered at the end of lessons; and b) the number of correct answers on 10-item, cumulative, pre- and post-science tests. Science lessons and assessment items were derived directly from the Science Education General Supervision of Kuwait, Ministry of Education (SEGS KW). Two elementary science teachers independently reviewed all of the evaluation materials prior to the commencement of the research. These two teachers reviewed the materials in terms of educational significance, clarity, accuracy, and consistency with curriculum goals. Reviewers' feedback was incorporated into subsequent material revisions.

Research Instruments

Daily quizzes and pre- and post-tests were used as study instruments to collect data. The items of these tools/instruments tested studied science lesson concepts and themes using the following methods: matching the correct word with the appropriate picture, filling in gaps with correct words/concepts, sorting concepts based on their characteristics, and completing sentences. Science topics were as follows: a) opaque and transparent objects; b) substance textures; c) light, shadow, and darkness; d) the four seasons; and e) animals' hides: skins, scales, wool, leather, fur, etc. Quiz items assessed the main ideas/concepts after each lesson, and items on cumulative pre- and post-tests reflected the "big takeaways/ideas" across all assessment content. (Samples of assessment materials are available from the first author upon request). The science teacher administered the quizzes after each science lesson, along with pre- and post-tests before and after the instruction with NHT for the experimental group. At the end of each class/session, the science teacher read aloud the quizzes, and students had to independently respond. This procedure was repeated after each science lesson. Prior to the initiation of the experimental, single-subject design procedures, and before the commencement of NHT instruction, the teacher administered the pre-test to collect the needed data on students' performances.

Inter-rater reliability

To ensure stability of the collected data, inter-rater/inter-scorer reliability checks were conducted throughout the research investigation on students' quiz scores. Before commencement of the data collection process, the first author trained the classroom teacher to score samples of science quizzes. Specifically, the teacher was first trained on how to review the criteria of scoring (i.e., a student matching line not pointed directly to the correct picture or missing main conceptual word[s] when defining terminologies would count as a wrong response, and a correct word underlined and/or written in the gap would count as a correct response) before the initiation of actual grading. Both the first researcher and the teacher marked samples until they reached 100% agreement on 10 consecutive items. Any items that were marked differently were thoroughly discussed until agreement was obtained. Then, both the first researcher and the teacher independently scored participant quizzes. Independent scoring was compared on an item-by-item basis (Kazdin, 2011). When both scores marked a response as correct or incorrect, it was marked as an agreement. If independent scores were different (one correct/one incorrect), it was marked as disagreement. Afterwards, inter-rater reliability was calculated using the following formula: number of agreements divided by number of agreements and disagreement × 100. As a rule, a minimum of 80% agreement is mandated for acceptable reliability coefficients (Huck, 2012). The reliability coefficient for the first dependent variable (number of correct answers on five-item science quizzes) was 94%, and the reliability coefficient for the second dependent variable (number of correct answers on 10-item, cumulative science pre- and post-tests) was 92%. Both coefficients fell above standard, indicating scores were trustworthy and consistent over time.

Independent variable

Explicit instruction (EI) is an evidence-based teaching approach, and it represents the first component of the interventional program. In EI, the instruction is carried out in three phases (Archer & Hughes, 2011). Students with and without special needs obtained opportunities to practice the learned skill and master by going through the three main phases (I Do: teacher's presentation/modeling), (We Do: both teacher and students work on the skill, the guided practice), and (You Do: students work on the skill individually/independently, the unguided practice).

Numbered Heads Together (NHT) without incentives served as the experimental/independent variable. The standards of NHT procedures were applied, consisting of four components: a) small, heterogenous learning groups; b) structured roles within the groups; c) positive interdependence; and d) identification of collective group performance. At first, the students were placed in small, heterogenous learning groups, consisting of four students each. When possible, the groups were heterogenous in terms of ethnicity and achievement levels, formed systematically (Kagan & Kagan, 2009). Each group involved at least one high achiever, average and low performing participant who sat in desk "clusters" during teacher-led instruction. The students were assigned numbers to follow the structured roles. Next, students were given dry erase whiteboards, markers, and cleaning cloths/erasers to write their individual responses. After the teacher's direct question(s) to the class (e.g., what is reptile skin covered with?), the students would write their individual responses on the boards and "put their heads together" in order to share information, finalize the group answer, or, when necessary, tutor one another. In each group, the four students would make sure that each member agreed on the best answer that was selected and written on the board. When the teacher randomly called a number from 1 to 4, all of the numbered students stood and their (decided) answer was written on the board. Other students would be asked if they agreed (i.e., how many number 3s agree?) or if they could add to this answer. The teacher then provided positive and/or immediate corrective feedback, and the students would give a round of applause/group cheers for correct answers.

Fidelity checklists were created to ensure that NHT was implemented as intended, and a fidelity check was conducted during the experimental phases. Another classroom teacher who was unfamiliar with the study purpose observed and recorded the presence or absence of NHT procedural steps. This was to some extent challenging at the beginning, because that teacher did not encounter NHT prior the research. She was not familiar with research phases either. The first researcher explained to her the procedural steps that she was required to carefully observe and mark their presence and/or absence. Fourteen procedural steps were listed in the checklist as the following: 1) Giving a signal for students to group activity, 2) introducing and/or reminding students with NHT, 3) giving instructions prior NHT: 4) a student should select a number tag from the number box on teacher's table, 5) a student puts on her number tag lanyard, 6) each student uses her self-white board pasted on the textbook cover back, marker and eraser, getting ready for the teacher's" Good to Go", 7) reviewing NHT, and students would cooperate in each group for answering teacher's questions, 8) attending teacher's question, 9) putting their heads to the group's classmates to discuss possible answer(s), 10) any student does not understand the question, the members cooperate to explain the question, giving further explanation/clarification(s), 11) sharing ideas on the self-boards, to reach a consensus, 12) writing the shared answer on the board, 13) getting ready to teacher's number calling on, 14) praising correct group answer and/or giving direct, corrective feedback when needed. Fidelity was calculated as the number of procedural steps present divided by the number of steps present and absent × 100. Fidelity obtained was 100%, indicating that the intervention was delivered with a high degree of accuracy. The fidelity checklist is available from the first researcher upon request.

Research procedures

As abovementioned, ethics of scientific research were followed before commencement of the research procedures. The research purpose and procedures received the College of Education Dean's approval, at Kuwait University. Then, an approval letter from the Dean's office was sent to the Superintendent of Elementary Level in Farwaniya School District. The district issued an approval letter, afterwards, to conduct the research. Once the approval received, the first researcher prepared the parent/legal guardian consent letters. Legal guardian consent letters were distributed to the participants by the science teacher and received the next day.

Prior to the pre- and post-test phase, single-subject (alternating treatment design) was used to compare student performances during the conditions of HR and EI with NHT without incentives. A single-subject (alternating treatment) design was used to provide descriptive and correlational information on the relationship of these two strategies in comparison to HR and to determine which one of the two (Interventional program or HR) was more powerful.

Hand raising [HR]. During this condition, the teacher taught the lessons using the typical instructional material (i.e., pictures, figures) and method (i.e., lecturing, didactic manner). The teacher then asked direct, content-based comprehension questions of the entire class and waited for students (usually between 3–5 seconds) for students to respond by raising their hands. After randomly selecting one student to respond, the teacher provided verbal (positive or corrective/constructive) feedback based on the student's response. If the student's response was incorrect, the teacher called on other students to provide the correct answer. At the end of the session, the teacher read aloud questions from the daily five-item quizzes, and students independently wrote responses. Quizzes were graded and returned the next day.

Student instruction/training. Participants were taught using the EI phases. The teacher taught the content in each class (modeled the skill) as assigned by the Science Supervision Annual Content Plan. After the modeling (I Do) phase, she asked participants to work with her on the same skill with different examples/exercises conducting the (We Do) phase. Then, giving students worksheets to work on the exercises/tasks independently, (You Do) phase. Feedback, and immediate correction was given when needed.

Prior to the initiation of NHT, the first author introduced and trained the classroom teacher on how to conduct NHT procedures. Afterwards, students were trained by the teacher on how to use NHT procedures during a 40-minute session. Students were placed into 5 four-member heterogenous teams and asked to move close to one another. As mentioned above, each group involved at least one high-achieving student, one average-performing student, and one low-performing student. These placements were done privately, and students were unaware of their science achievement statuses. Additionally, each student was assigned a number from 1 to 4. The teacher then described and explained the procedures of NHT, and how they could be used during the upcoming science lessons. During the training phase, participants were presented with an 8, sample science quiz, during which they practiced NHT procedures. After each question, they were asked to "put their heads together," come up with the best answer(s) they could, discuss and share responses, finalize their agreed-to answer, and write it on their boards. The teacher randomly called a number from 1 to 4. All students who had that number would stand and share their determined answer. The teacher provided positive, immediate, and corrective feedback. She also gave them feedback on the accuracy of the students' NHT procedure implementation. Formal data collection initiated after the training phase, and when students demonstrated correct, accurate performances of NHT procedures.

NHT. During NHT, instructional materials, time, and methods (i.e., didactic) remained constant. As mentioned above, the students were placed in heterogenous, four-member learning groups, and sat in small clusters. Each student was given a number from 1 to 4, and group membership remained the same throughout the context of the study. The teacher asked the questions, and the students were asked to put their heads together, share their best answer, offer quick tutoring to the group members when needed, jot down the final answer, and get ready for the calling of numbers. The wait time given to students to share and discuss was 30 seconds. Then, the teacher said, "All number (1s, 2s, 3s, or 4s) stand up and share your answer to the class." To ensure that the other students knew the answers, the teacher asked, "How many other similar number (1, 2, 3, or 4) students agree with that answer?" Feedback regarding students' responses was provided. At the end of each NHT session, students were asked to independently complete five-item quizzes using procedures identical to the HR condition.

For the quasi-experimental part of the methodology, both control and experimental groups took the pre- and post-test exams. Before the commencement of the study phases, the classroom teacher administered a 10-item cumulative science pre-test for both groups/classes. For the experimental group, participants adhered to single-subject procedures, and afterwards were administered the cumulative science post-tests, similar to their peers in the control group.

Data Analysis and Results

Data were analyzed by calculating the averages of daily quizzes of students across the two research conditions of HR and (EI & NHT) during the single-subject design/method. For the quasi-experimental method, t-tests were used to derive statistical differences between the control and experimental groups in the acquisition of the learned knowledge/content of science, as displayed in the results of pre- and post-tests. Another method of calculating effect size (Cohen's d) was used to see the effects of the intervention. The results of the data analyses are presented in alignment with the research questions.

1) What is the impact of EI and NHT (without incentives) on the number of correct answers per daily science quizzes of the participants?

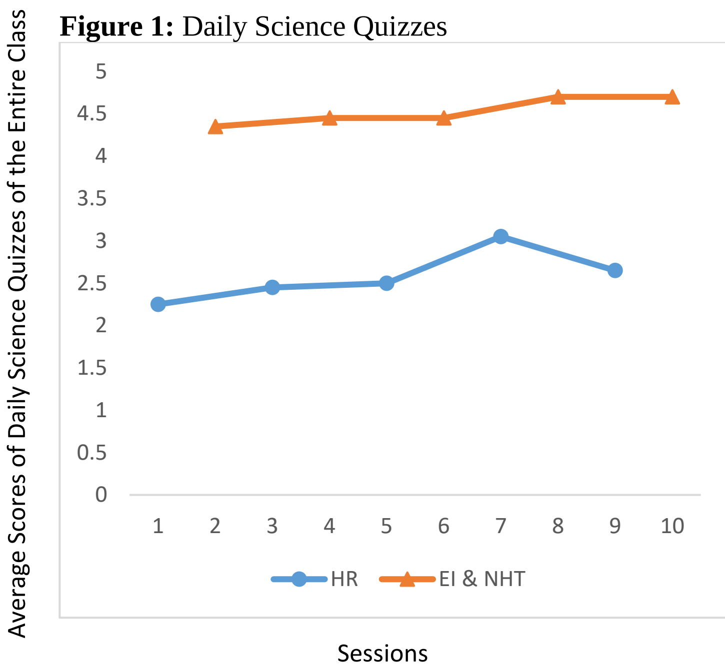
As depicted in Table 2, the entire class increased their average scores when the EI and NHT were implemented. Students increased their average score to 4.35 during the first session of EI and NHT in comparison to the first session of HR (2.25). During the last two sessions of EI and NHT, students improved their average scores to 4.7 (from 3.05 and 2.65 during sessions 4 and 5 of HR, respectively). As noted, class performance was to some extent low during the HR

condition, while the class improved their average range during EI and NHT sessions (4.35–4.7).
When considering individual students' average scores, these were accelerated on the days/sessions of EI and NHT in comparison to HR. Students with or at risk of disabilities also accelerated their average scores during EI and NHT.

Table 2: Entire class averages on daily, science quiz scores across experimental conditions per session

Sessions	HR	EI & NHT
1	2.25	4.35
2	2.45	4.45
3	2.5	4.45
4	3.05	4.7
5	2.65	4.7

Figure 1: Daily Science Quizzes



2) Are there any statistical differences between the control and experimental groups in the acquisition of the learned content?
T-tests were used to determine if there were statistical differences between the control and experimental groups in the acquisition of the learned knowledge/content of science, as displayed in the results of pre- and post-tests. Table 4 indicates that there were statistical differences at $\alpha = 0.05$ between the experimental and control group, and these differences were due to the intervention (EI & NHT), which was presented for the experimental group. For the post-tests, t-test value was 7.070, and statistical difference reached 0.000. The result indicated $p = 0.000 < 0.05$, which showed that there were statistical differences between the two groups for the sake of the experimental group. Additionally, the mean score of the experimental group was 8.40, with a standard deviation of 0.995 in comparison to the control group's mean score of 5.55 and standard deviation of 1.504. These scores demonstrated that the experimental group performed significantly better than the control group in the acquisition of science learning content/knowledge. Results showcased that the performance of the experimental group (including students with disability and/or at risk of school failure) was higher than that of the control group due to EI and NHT, in comparison to the control group's performance.

Table 3: Individual student averages on daily science quizzes across experimental conditions

Participants	Experimental Conditions	
	HR	EI & NHT
1	2.4	4.6
2	2.4	4.8
3	2	4.6
4	1.6	4.8
5	1.4	3.6
6	2.4	4.6
7	3.2	5
8	1.8	4.4
9	1.8	4.2
10*	2.8	4.4
11	2	3.6
12	2.8	4.2
13*	3.4	4.8
14*	1.8	4
15	3.2	5
16	2.6	4.4
17	3.6	4.8
18	3.4	4.8
19	3.2	5
20	2.4	4.6

Note. Asterisk indicates students with and/or at risk of disabilities.

Table 4: T-test for Both Experimental and Control Groups' Post-Tests.

Measure	Group	N	Mean	Standard Deviation	T-Value	Statistical Significance P value
Post test	Experimental	20	8.40	.995	7.070	0.000

Control	20	5.55	1.504

3) Are there any statistical differences between the control and experimental groups' pre- and post-tests? T-tests were used to calculate and analyze data for the third research question, which concentrated on exploring whether there were differences between the control and experimental groups in their pre-tests. As displayed in Table 1, there were no statistical differences at α = 0.05 for the instruction presented, for both control and experimental groups. T-value reached 0.717), with statistical significance p= 0.478 > 0.05. It was thus concluded that there was no significant difference between the two groups in the acquisition of the learned skills in their pre-tests. The experimental group achieved a mean score of 5.30 and standard deviation of 1.809; this approximates the performance of the control group, which obtained a mean score of 5.70 and standard deviation of 1.719. This indicates that both groups' performances were similar to each other before the introduction of EI and NHT.

For the post-tests, however, there were significant differences between the two groups at α = 0.05 due to EI and NHT presentation to the experimental group, as shown in Table 5. The t-value reached 4.822, with a statistical significance of 0.000, and it was less than 0.05, p = 0.000 < 0.05. This indicates that there were statistical differences between the pre- and post-tests, with such differences relevant to the post-test scenario. In addition, the mean score for the pre-test was 5.5000, with a standard deviation of 1.754; the mean score notably increased in the post-test, reaching 6.9750, with a standard deviation of 1.914. This finding demonstrates that the intervention highly accelerated the participants' performances in the experimental group in comparison to their peers in the control group. Students with and without special needs in the experimental group improved their science content acquisition and academic achievement/performance when they experienced EI and NHT.

Table 5: Paired Sample T-Test for the Pre and Post-Tests Differences

Measure	Test	N	Mean	Standard Deviation	T-Value	Statistical Significance P value
Achievement Test	Pre-test	40	5.5000	1.754	4.822	0.000
	Post-test	40	6.9750	1.914		

4) What is the effect degree (or effect size) of the experimental group performance and after the delivery of the intervention?
Table 6 displays the effects size (Cohen's d) of the intervention presented to the experimental group. Cohen's d reached 0.8, and the t-value of the post-test for the achievement test reached 4.822. This result indicates a large effect size for the intervention.

Table 6: Degree of Effect of the Intervention for the Experimental Group's Post-Test

Measure	T-Value	Cohen's d	Degree of Effect
Achievement Test: Post-test	4.822	0.8	Large

5) From a social validity standpoint: How did the classroom teacher perceive the EI and NHT in learning scientific concepts/themes?

To derive social validity data regarding the intervention, the first researcher conducted an interview consisting of three open-ended questions with the science teacher who delivered EI and NHT. The teacher indicated that both EI and NHT were easy to implement and very straightforward ways of teaching. She stated:
Modeling the skill (EI) and instructing the students step by step were always called as old-fashioned ways of teaching, unfortunately. Additionally, this is the first time I know that group activity (NHT) which included the step by step, clear modeling (by student to her peer) is an evidence-based instructional strategy. How it shouldn't be? It benefited ALL my students! I have students with disruptive behaviors (like: yelling for having turn to answer, walking around in class), along with those with learning disabilities. I noted they were all engaged when EI and NHT were there. They attended my instruction and comprehended the skills and worked hard with their classmates.
The teacher also brought up an interesting point regarding NHT, which emphasized all of her students'

active learning, engagement, and class participation. She stated:

At the beginning, I had this feeling that NHT could be hard to implement. I have never encountered it. I have never tried it. Yet, the surprise was it was easy to implement. When I gave instructions/tasks of it every time from the script you gave me, the students started rehearsing the instructions with me! They memorized them, knowing what to do, how to collaborate with their classmates and finalize their answers. It was interesting to see how they helped each other with the correct answers. I noted a few (like those high achievers remodeling the concept over and over again to their classmates (with disability and/or at risk of school failure), in a very quick manner while working in NHT to finalize their answer.

Discussion

The main goal of the current research was to explore the effects of EI and NHT to see if they would impact students with and without disabilities' academic achievement in science. All of the students in the experimental group benefited from the intervention, increasing their achievement through their encounter with this powerful instructional program. It is interesting to note that the intervention produced immediate improvements both in students' daily quiz scores and in cumulative post-tests. It is also notable that NHT improved student performance substantially without using incentives (i.e., tokens), which corresponds with prior NHT research (Johnson et al., 1983; Kagan & Kagan, 2009). As previously indicated by Heward and Wood (2015), following the simple procedures of NHT (i.e., students putting their heads together, sharing and discussing answers) in order to reach a final consensus on the teacher's questions noticeably increased students' performance, motivating them to carefully attend to the teacher's instruction and to perform well in the group activity of NHT afterwards.

Indeed, while the present investigation provides replicated, positive results of the instructional program on students' academic performance and active engagement, it is novel to witness such an endeavor in Kuwaiti public general education classes. In its supervision of subject areas, the Ministry of Education is constantly looking for innovative instructional strategies, claiming that teacher's modeling, as indicated by the classroom teacher, is an "old-fashioned" way of instruction. Nevertheless, the teacher's role is vital. The implementation of evidence-based instructional strategies requires highly qualified teachers skilled in such instruction and in creating an engaging, interactive learning environment for all students, including those with special needs (Archer & Hughes, 2011; McMillen et al., 2016; Rosenshine, 1987).

Here, students with and without disabilities experienced an EI and NHT condition in which they learned the skill(s) deeply through the phases (I Do, We Do and You Do) of EI and then cooperatively worked with their classmates in NHT to produce correct answer(s) and saw their peers re-instructing/modeling/discussing the concept/theme when needed. This result extended the positive effects showcased in previous literature. Additionally, it corresponds with Haydon et al.'s (2010) findings that NHT resulted in unique outcomes—namely, immediate and noticeable gains in participants' academic performance, and reduction(s)/decrease in the disruptive behaviors of some students. In NHT, students were given time to discuss and formulate responses before being asked or prompted to answer, as in hand-raising condition, for instance: "As such, the putting your heads together process may have served as a form of pre correction for pupils when formulating responses" (Haydon et al., 2010, p. 235). They would correct each other's answers, hear more accurate responses, or simply be quickly instructed (Maheady et al., 2006), viewing the modeling for the second or third time in a class. As a result, students would be unable to predict who would be chosen to answer; with the random calling of team member numbers, all pupils in the teams would be alert, paying better attention and having more opportunities to respond than with the hand-raising [HR] technique (Kagan, 1992; Maheady et al., 2002). All of the students had the opportunity to agree or disagree with an answer, share ideas, discuss concepts, and have a turn to respond (McMillen et al., 2016).

Limitations, Implications and Recommendations

Certain limitations should be considered when interpreting the current research results. One notable limitation was regarding the interventional program. Implementation of evidence-based instructional program consisted of two strategies: EI and NHT, it could be difficult to know which component contributed more to the increase of results. In other words, the researcher could not know which strategy was more effective than the other and/ or had greater impact on the dependent variables. Another salient limitation was the sample representation. The current research used a sample of convenience. Forty, 4th grade students were divided into two groups: experimental and control, in mixed methods, single-subject, alternating design and quasi-experimental. The sample size made it challenging to generalize the study's findings to larger population. A third limitation noted was the inability to collect follow-up data because of out-of-control circumstances (i.e., Spring break, National and Liberation Day Holidays). These breaks delayed the time of the study commencement and/or phases which led to inability to collect maintenance data. It would be more effective to see if the participants could maintain the learned skills overtime, by measuring follow-up their performances. Follow-up measurements help in knowing whether students, especially with special needs could remember the studied skills, and use them later.

The evidence-based intervention (EI & NHT) used in the study represented a promising instructional program to teach science to all students with and without special needs in inclusive classrooms. Kuwaiti Educators should consider researching EI and NHT separately in their future research endeavors. The impact of EI along with NHT could be studied to identify what areas of science curriculum they would improve. Findings of the current study revealed that the interventional program was effective, powerful, economical and easy to implement in comparison, to technological tools which are mandated by many Kuwaiti science supervisors when visiting teachers in their classroom. EI shows the procedural steps, analyzing the task, clearly in very durable, detailed way so students with and without special needs could absorb the learned skill easily. Additionally, NHT encouraged the team-work, and collaboration spirit among all students. Students with special needs felt home, secured when their classmates in the groups were further explaining concept/theme. Students had shared responsibility when providing answers to teacher's questions. This encouraged the idea of contingency management in which each member is responsible of the classmate's success (Maheady et al., 2002). All students with and without special needs benefited from the instructional program. This finding implies that it is advisable for Kuwaiti educators, in-service teachers to adopt evidence-based instructional strategies for delivering learning content. Educational policymakers could also modify the codes/laws by mandating teacher preparation programs at public universities/colleges to prepare future teachers on how to use/implement these strategies in real contexts. Furthermore, it is recommended that future research focuses on investigating the generalizability of EI and NHT in other subject areas including social studies, Arabic language Arts, and mathematics. It is highly recommended to see the results of both EI and NHT on performances of other students with special needs' performances (i.e., with behavioral problems, visual impairments) and how such interventional program could keep students on behavioral and academically on track.

Conclusion

In conclusion, prior research displayed the effects of evidence-based instructional strategies for students with and without special needs, in different settings involving general and/or inclusive learning environments. Effective strategies permit teachers to educate students with wide-ranging abilities, delivering the learning content in various settings such as general education classrooms (Hughes et al., 2022). Participants could observe the taught skill and experience it, receiving needed scaffolding to master the skill during EI activity. Afterwards, the students engaged in active participation and had the opportunity to nurture their social skills (i.e., discussing, agreeing, respecting others' ideas, cooperating, and reducing disruptive behaviors) during NHT. Future research and practice should further explore the use of EI and NHT to strengthen students' learning outcomes.

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