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Comparative Effectiveness of Indirect and Direct Teacher-Student Interaction Patterns in Science Instruction

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ABSTRACT

Using an experimental research design, this study aimed to determine the effectiveness of indirect and direct teacher-student interaction patterns in the acquisition of science concepts and science process skills of two matched groups of the first year Bachelor of Elementary Education (BEEd) students of the Mariano Marcos State University College of Teacher Education. Both groups were pre- and post-tested using science concepts and science process skills tests. Mean was used to describe the performance of the students in both tests. The t-test was used to determine the significant difference between the pretest and posttest mean scores of the two groups. Results of the t-test showed no significant difference in the pretest mean scores of both tests while in the posttest, the indirect interaction group performed satisfactorily as compared to the direct interaction group where there were students who performed fairly in both tests. Thus, the t-score of the indirect interaction group was significantly higher than that of the direct interaction group. Indirect teaching is therefore more effective than direct teaching in the students' acquisition of science concepts and science process skills. Thus, it should be given emphasis for the effective acquisition of science concepts and science process skills.

INTRODUCTION

According to the Philippine Science Curriculum Framework for basic education developed by the Department of Science and Technology and UP National Institute for Science and Mathematics Education Development (2011), science is useful because of its links to technology and industry, which, from a national perspective, are areas of high priority for development. According to Singh (2021) Science is one of the most important subjects in school due to its relevance to students' lives. It uses and develops applicable problem-solving and critical thinking skills. These are lifelong skills that allow students to generate ideas and to make wise and informed decisions. Studies indicate however, that many of the Filipino learners are not attaining functional literacy, thus they find it too difficult to meet the challenges posed by our rapidly changing world.

According to a statement issued by the Department of Education on December 4, 2019, the Programme for International Student Assessment (PISA) 2018 revealed that the Philippines performed poorly among 79 Organization for Economic Cooperation and Development (OECD). The Philippines was ranked 79th in reading, with a score of 340, compared to the OECD average of 489. Filipino students also performed poorly in mathematics and science, scoring 353 and 357 points, respectively, compared to the OECD average of 489 points in both categories.

Results of the 2018 National Achievement Test (NAT) for Grade 10 learners invariably performed way below the level of acceptable MPS in all subject areas. Learners obtained the mastery level index of "Average Mastery" (AM) in all tested learning areas except Mathematics with a low mastery level. With regard to the NAT Grade 12, Mathematics and Science registered the lowest among the tested learning areas. Also, Grade 12 learners invariably performed way below the level of acceptable MPS in all subject areas.

With these results reflecting the learners' performance, the Department of Education (DepEd) is aware of the pressing need to address problems and gaps to ensure the Philippines has access to high-quality basic education. One of the four important reform areas of the *Sulong Edukalidad* is the improvement of the learning environment. The Science teacher should be personally concerned and committed in providing quality science education. The Science teacher should provide meaningful experiences to the learner which allow the learner to have a hands-on, minds-on and hearts-on experience in Science that spark student's interest and invoke student's thoughts and creation of positive classroom environment. So, the quality of Science education has something to do with how Science is taught. Teachers must be reoriented in the way Science should be taught-through inquiry, discovery, demonstration, practical work, laboratory, and other hands-on approaches. Antonio (2018) found out in her study that students consider the laboratory part of every Science subject very important and very interesting since these make them work and discover things on their own, enhance their skills and do not limit their explorations, excite and make them feel very eager specially in using or manipulating lab equipment and materials like chemicals, and let them discover a lot about things they pass by or ignore everyday which usually ordinary yet very useful. There is a creation of a deeper sense of learning among students whenever they perform such activities. Shanah

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and Abulibdeh (2020) stresses that students be given ample opportunity to be engaged in practical lessons for greater Science achievement. This makes learning more meaningful because the learner is taught the process of acquiring learning rather than mere concepts. In support to this, Batuyong and Antonio (2018) cited that student engagement when enhanced tend them to try more, work more and learn more about the assigned tasks in the activities. Thus, their concept that a subject is hard is changed to be an interesting, exciting and enjoyable subject to learn.

So, there is an element in the classroom environment and in the teaching-learning process that may influence students' learning to a greater extent which is often left untouched. This is the teacher-student interaction. Thus, it would be wise to study classroom interaction patterns and measure the effectiveness of the interaction patterns to performance of students.

The abovementioned reasons motivated the researchers to conduct the present study which is focused on the comparative effectiveness of indirect and direct teacher-student interaction on the performance of students in terms of acquisition of science concepts and science process skills.

Specifically, it tried to determine the following

1. Initial performance of the two groups for their pretest scores in the test on science concepts and science process skills;
2. Initial and final performance of the indirect and direct interaction group for both tests; and
3. Final performance of the two groups for their posttest scores for both tests. The comparative effectiveness of the indirect and direct teacher – student interaction is determined in terms of the t-test of difference between the posttest mean scores of the indirect and direct interaction groups in the test on science concepts and process skills.

LITERATURE REVIEW

Science education in the Philippines aims to achieve several key goals. Firstly, it seeks to develop scientific literacy among students, ensuring they grasp the principles, concepts, and applications of science, as well as understand the nature of science and its societal role. Secondly, the education system aims to prepare students for higher education and careers in science and technology by providing them with a strong foundation in the sciences and related fields. Thirdly, Science education in the Philippines promotes scientific inquiry and critical thinking skills that can be applied in various academic and real-world situations. Lastly, the curriculum emphasizes the importance of instilling ethical values and social responsibility in students, encouraging them to utilize scientific knowledge for the betterment of society and the environment.

In the pursuit of knowledge, teachers play a crucial role in shaping the quality of citizens, as emphasized by Magnaye (2022). The education provided by teachers significantly influences the development of individuals and ultimately impacts society. Teachers have the responsibility of imparting knowledge, skills, and values to their students, equipping them with the necessary tools to become informed, responsible, and active members of society.

Calzada and Antonio (2023) outlined the long-standing issues in the education sector have remained unaddressed despite the implementation of the K to 12 curriculum. Problems such as the shortage of classrooms, textbooks, seating, and toilets in public schools persist (Navarro, 2022). Teachers continue to face overwhelming teaching loads (Esguera, 2018), challenges in following the spiral progression approach in teaching (Dunton & Co, 2019), and a lack of instructional materials (Soriano & Vargas, 2021). Furthermore, large class sizes (Esguera, 2018) and insufficient training for teachers (David & Vizmanos, 2019) continue to be prevalent issues.

This study is based on three theories: (1) Flanders' Interaction Analysis System, (2) Froebel's Theory of Self-Activity, and (3) Bruner's Discovery Learning. According to Flanders, teachers who use indirect influence are more effective in teaching and facilitate greater learning compared to those with a direct approach (Lorenzo, 1988). An indirect teacher accepts and values students' feelings, ideas, and encourages open-ended questions that promote deeper understanding. This approach maximizes students' freedom to respond and actively engage in the learning process, leading to a more positive attitude towards the teacher and the learning activities (Graham, 1998). On the other hand, a direct teacher minimizes student responses, and according to Flanders' Interaction Analysis System, most of the classroom time is dominated by the teacher talking, primarily expressing facts, opinions, giving directions, and criticizing students. This results in passive learning for students (Graham, 1998). Moreover, Flanders' theory highlights the effectiveness of indirect teaching methods, where teachers value student input and promote active engagement. In contrast, direct teaching methods limit student responses and lead to passive learning.

For learning to be effective, it should be an active and dynamic process. It is crucial that learning begins with the learner and is self-initiated. Rather than simply memorizing rules or observing others, true learning occurs when individuals actively engage in doing the task themselves. They learn through the actual experience and practice of specific actions or reactions. It is important to note that the responsibility for learning lies with the learner and not with the teacher. The teacher's role is to facilitate learning through effective teaching methods. Therefore, emphasis should be placed on indirect teaching approaches, where the teacher guides and supports the learner in their journey of acquiring knowledge and skills.

Indirect teaching draws on Friedrich Froebel's theory of self-activity, which asserts that learning occurs exclusively through personal engagement (Gregorio, 1976). This theory is based on the notion that individuals acquire knowledge more efficiently when they actively participate in activities or personally experience various situations. The level of student involvement directly correlates with the extent of learning, as active participation leads to a more rapid learning process. In this approach, learning primarily involves actively performing the tasks to be learned. First-hand experiences contribute to a more comprehensive understanding. In essence, learning is most effective when it adheres to the theory of self-activity. Thus, the learning process fundamentally revolves around experiencing, reacting, doing, and comprehending (Gregorio, 1976).

Self-activity in education encourages students to engage both their hands and minds, providing them with hands-on and minds-on experiences. This approach not only enhances cognitive understanding but also develops process skills necessary for carrying out activities. The acquisition of process skills is best achieved through active participation rather than passive observation. It is through personally engaging in activities that require the application of process skills that individuals truly learn them. Consequently, emphasizing indirect teaching methods becomes crucial for promoting a deeper understanding of concepts and the development of essential process skills.

Indirect teaching, supported by Flanders' Interaction Analysis System and Bruner's Discovery Learning, emphasizes the importance of active engagement and hands-on experiences in the learning process. Both theories stress that learning is enhanced when individuals personally experience and engage with concepts and skills through active participation. By emphasizing indirect teaching methods, students can develop a deeper understanding of the subject matter. This approach promotes meaningful and effective learning experiences by encouraging students to learn through doing and experiencing first-hand.

Bruner provides four reasons for advocating the use of discovery learning: intellectual potency, intrinsic motivation, learning the heuristics of discovery, and memory retention. Intellectual potency refers to the idea that individuals truly develop their minds by actively using them. Through successful discovery, students experience a sense of intellectual fulfillment, which serves as an intrinsic reward. Furthermore, the only way to learn the techniques of making discoveries is by having opportunities to engage in the process. Discovery learning also facilitates the development of process skills as students learn how to organize and conduct investigations. Lastly, one of the significant benefits of discovery learning is its positive impact on memory retention. Concepts that are experienced through discovery tend to be better retained compared to concepts that are simply told or taught. In summary, discovery learning promotes intellectual growth, intrinsic motivation, acquisition of problem-solving skills, and improved memory retention (Carin & Sund, 1975).

Discovery learning provides opportunities for greater involvement thereby giving students more chances to gain insights as they actively interact with their environment. This makes learning achieve effective result. Moreover, discovery learning encourages students to actively use their intuition, imagination, and creativity.

The theories of self-activity by Froebel and discovery learning by Bruner share commonalities with Ned Flanders' indirect teaching approach. When a teacher employs indirect teaching, they align with the principles of self-activity and discovery learning. Discovery learning emphasizes self-activity by placing the learner at the center of instruction. Through the process of discovery, learners personally experience and engage with the subject matter, leading to meaningful education. Active participation is crucial for significant learning outcomes. Consequently, when students are given the opportunity to discover through self-activity, their performance improves in terms of understanding science concepts and developing science process skills.

In the realm of science education, student participation plays a vital role because knowledge originates from experiences. Science cannot be learned solely through memorization of facts, concepts, and principles; it requires the integration of experiences. Thus, classroom interaction becomes essential, maximizing student participation. However, the effectiveness of indirect and direct teacher-student interaction in terms of enhancing students' knowledge of chemistry concepts and science process skills still requires empirical evidence.

Classroom interaction is an essential part of the teaching-learning process. Thus, an effective classroom interaction is needed for better performance of students in terms of knowledge of science concepts and science process skills. Guided by Flanders' Interaction Analysis, Froebel's Theory of Self-Activity and Bruner's Discovery Learning, an experiment was conducted to compare the effectiveness of indirect interaction and direct interaction on the performance of students in chemistry in terms of knowledge and science process skills.

MATERIALS AND METHODS

This research made use of the two-group pretest-posttest experimental design since its aim was to determine the comparative effectiveness of indirect and direct teacher – student interaction patterns in science instruction in the acquisition of science concepts and science process skills.

This study was conducted in Mariano Marcos State University College of Teacher Education Laoag City. The college is a pre-service training institution for secondary and elementary teachers. The college is the Center of Academic Excellence in Teacher Education in Region I.

Two regular first year BEEd classes composed the population of this study. Twenty students from each section were selected through random sampling and were matched based on their grade average in high school Science and Technology IV. Assignment of type of interaction, whether indirect or direct was done by tossing a coin. The twenty students of each group were mixed with the other students in their section in order to avoid students' awareness of experimentation and investigation.

This research utilized the following instruments: 1) Test on Science Concepts; and 2) Test on Science Process Skills; and Flanders' Interaction Analysis System. The test on science concepts and science process skills test were given as pretest and posttest for both groups. The Flanders' Interaction Analysis System was utilized as a guide for the researcher in preparing the lesson plans.

The same lessons and activities were given for both groups. However, the indirect interaction group was student -centered while the direct interaction group was teacher-centered. The lessons included were the topics in Unit II: Nature of Matter of the Syllabus in Science 3. The data gathering for the classroom interactions lasted for four weeks. All the activities that were administered to the two groups were the same except for the kind of interaction that prevailed in the class.

Mean and standard deviation were used to describe the level of performance of the students in knowledge on science concepts and science process skills in the indirect interaction and direct interaction groups. In the inferential aspect, the t-test was used to determine any significant difference between the pretest and posttest mean scores of the two groups along the knowledge on chemistry concepts and science process skills.

RESULTS AND DISCUSSION

Initial performance of students. Comparison of the pretest results revealed no significant difference on the initial performance in knowledge on science concepts and science process skills of the indirect and direct interaction groups. This indicates that the groups were comparable in terms of their initial understanding of the subject matter.

Table 1 shows the comparison of the pretest mean scores of the direct and indirect interaction groups in the test on science concepts and science process skills.

Table 1: Results of the t-test of difference between the pretest mean scores of the indirect and direct interaction groups in the test on science concepts and science process skills

Test	Indirect Interaction Group	Direct Interaction Group	Difference	T-Value
Science Concept	32.60	29.60	3.00	1.660**
Science Process Skills	58.00	54.80	3.20	1.144**

****p < .01 Critical Values: (2-tailed, df = 38, a = .01) = ± 2.713 (2-tailed, df = 38, a = .05) = ± 2.025*

Effectiveness of the indirect teacher-student interaction and direct teacher-student interaction patterns.

The t-test of difference as shown in Table 2 revealed that the posttest scores of the indirect interaction group was significantly higher than the pretest both in the test on science concepts (t =10.231) and science process skills (t=8.971). This implies that the students in indirect interaction group significantly improved their performance in the posttest indicating that indirect interaction was effective in helping the students acquire science concepts and science process skills. Indirect teaching actively and directly involved the students in the learning process. Thus, learning becomes effective because the greater the involvement of the students.

Table 2: Results of the t-test of difference between the pretest and posttest mean scores of the indirect interaction group in the test on science concepts and science process skills

Test	Pretest Mean Score	Posttest Mean Score	Difference	t-value
Science Concept	32.60	29.60	3.00	10.231**
Science Process Skills	58.00	68.20	10.20	8.971**

****p < .01 Critical Values: (2-tailed, df = 19, a = .01) = ± 2.861 (2-tailed, df = 19, a = .05) = ± 2.093*

When students are actively involved in their learning, they become more invested in the subject matter. They are encouraged to ask questions, seek answers, and actively participate in discussions and activities. This level of involvement and engagement leads to greater motivation and a deeper connection to the content being learned.

Through the process of self-activity, students are able to construct their own knowledge and develop a sense of ownership over their learning. This active involvement enables them to make connections between concepts, apply their learning to real-world situations, and develop a deeper understanding of the subject matter.

By actively involving students in the learning process, indirect teaching taps into their natural curiosity and encourages them to become critical thinkers and problem solvers. It promotes higher-order thinking skills, such as analysis, synthesis, and evaluation, as students are challenged to explore and make sense of complex ideas and information.

The obtained t-value for the direct interaction group as shown in Table 3 likewise revealed that the posttest scores were significantly higher than their pretest scores in the test on science concepts (t=9.125) and science process skills (t=4.540).

Table 3: Results of the t-test of difference between the pretest and posttest mean scores of the direct interaction group in the test on science concepts and science process skills

Test	Pretest Mean Score	Posttest Mean Score	Difference	t-value
Science Concept	29.60	39.90	10.30	9.125**
Science Process Skills	54.80	61.25	6.45	4.540**

***p< .01 Critical Values: (2-tailed, df = 19, a = .01) = ± 2.861 (2-tailed, df = 19, a = .05) = ± 2.093*

This implies that direct interaction was also effective in teaching science concepts and science process skills.

However, a comparison of the t-value of the indirect interaction group (t=10.231) and the direct interaction group (t=9.125) of the pretest and posttest mean scores of the test on science concepts revealed no significant improvement in the performance of the students in the direct interaction group, also with the t-value of the pretest and posttest mean scores of the science process skills test. The t-value of the indirect interaction group (t=8.971) is higher than the t-value of the direct interaction group (t=4.540). This means that direct interaction pattern was not effective in increasing the students' level of performance in knowledge on science concepts and science process skills.

Comparative Effectiveness of Indirect and Direct Interaction Patterns

The posttest mean scores of the indirect interaction group both in the test on science concepts (47.7) and science process skills test (68.2) as shown in Table 4, were significantly higher than those of the direct interaction group (39.9 and 61.25). This means that indirect interaction pattern was more effective in the students' acquisition of science concepts and science process skills than the direct interaction pattern.

Table 4: Results of the t-test of difference between the posttest mean scores of the indirect and direct interaction groups in the test on science concepts and process skills

Test	Indirect Interaction Group	Direct Interaction Group	Difference	t-value
Science Concept	47.70	39.90	7.80	2.564**
Science Process Skills	68.20	61.25	6.95	2.372**

*** p < .01 Critical Values: (2-tailed, df = 38, a = .01) = ± 2.713 * p < .05 (2-tailed, df = 38, a = .05) = ± 2.025*

The results suggest that indirect interaction, characterized by active student involvement and self-activity, was more successful in promoting students' understanding of science concepts and their ability to apply science process skills. This implies that teaching methods that encourage students to actively participate in their learning, explore, and discover on their own can lead to more effective learning outcomes. This coincides with the study of Ruutman and Kipper (2011) that indirect instruction is an approach to teaching and learning in which concepts, patterns and abstractions are taught in the context of strategies that emphasize concept learning, inquiry learning and problem-centered learning.

The success of indirect interaction in enhancing students' acquisition of science concepts and process skills highlights the importance of student-centered approaches. By placing students at the center of the learning process and empowering them to take an active role, teachers can foster deeper engagement, critical thinking, and a sense of ownership over learning outcomes.

Indirect interaction encourages students to think critically, analyze information, and apply their knowledge to solve problems. The significant difference in posttest scores suggests that students in the indirect interaction group were able to develop higher-order thinking skills more effectively. This has important implications for their future academic and professional success, as these skills are essential in navigating complex and ever-changing environments.

The success of the indirect interaction group may be attributed to the emphasis on hands-on experiences and real-world applications. By actively engaging in activities and experiencing the concepts firsthand, students were able to develop a deeper understanding of science concepts and process skills. This highlights the importance of providing students with opportunities for experiential learning and practical application of knowledge.

CONCLUSION AND RECOMMENDATIONS

Based on the findings of the study, the following conclusions were drawn. The indirect teacher-student interaction pattern is effective in the acquisition of science concepts and science process skills. Indirect teacher-student interaction pattern enhances existing knowledge on science concepts and science process skills resulting to students' higher level of performance. It proved to be more effective than the direct teacher-student interaction pattern in the acquisition of science concepts and skills. Maximizing student participation tends to develop more positive attitude towards the teacher and the learning activities since his feelings are accepted, recognized and his ideas are used by the teacher making the student more confident to learn. This made learning more effective. Whereas a teacher who monopolizes class time talking forces the students to become passive learners. They do not develop a positive attitude towards the learning situation which adversely affects their performance. The results of this study affirm the theories of Ned Flanders, Friedrich Froebel and Jerome Bruner that students learn best when they are actively involved in the learning process. The greater the student involvement, the greater the learning because learning proceeds rapidly in direct proportion to active participation.

In the light of the findings and conclusions, the following recommendations are offered. Indirect teaching should be utilized more than direct teaching for effective acquisition of concepts and skills. This can solve the problem regarding the lack of mastery of skills of Filipino students and thus, the low performance of Filipino students in science. School administrators should encourage their teachers to be more indirect than direct. Thus, support should be given to teachers for activities in the classroom which enhances indirect teaching. This can mean the purchase of more equipment in the laboratory for science classes and even for other courses in the college. A similar study should be conducted to other courses to find out the effectiveness of indirect teaching to non-science courses. Also, to classes in the secondary level since the study was in the college level. Seminars and workshops should also be conducted particularly for teachers who are not well acquainted with indirect teaching for them to appreciate the importance of indirect teaching and academic gain. They should likewise be oriented on how to use the Flanders' Interaction Analysis System so that they can have objective feedback of the kind of interaction pattern they have in their classrooms. Curriculum materials like sample lesson plans which promotes indirect teaching guided by the Flanders' Interaction Analysis System should be developed so that teachers can have a ready reference and guide on how to implement indirect interaction pattern in the classroom, as well as to enhance the science courses syllabi. Teacher Training Institutions like the MMSU-College of Teacher Education should emphasize the use indirect interaction pattern in the classroom. Students should be exposed to indirect teaching. Also, Flanders' Interaction Analysis System (FIAS) should be included as a lesson in the Principles and Methods of Teaching.

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