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Spiral Progression Approach for Improving Students' Retention in Statistics and Probability

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Abstract*—This study looked into numerous academic domains, including engineering, physics, and the social sciences, place a high value on statistics and probability research. The high dropout and low retention rates that result from these disciplines are due to how challenging they are for students to learn. A number of teaching strategies, most notably the Spiral Progression Approach (SPA), have been developed to solve this problem. The Spiral Progression Approach, a teaching strategy that builds on existing knowledge and abilities and reinforces concepts via repetition, presents and revisits ideas in a cyclical fashion. Because it promotes deeper learning and allows for ongoing engagement with the material, this approach is expected to increase student retention. The Spiral Progression Approach's effectiveness in boosting student retention in Statistics and Probability has not received much research despite its potential advantages.*

***Keywords*—** *Approach, probability, student, retention, spiral progression, probability.*

I. INTRODUCTION

Many students struggle with understanding and applying statistical concepts, which can negatively affect their academic performance and retention in statistics courses (De Lange et al., 2018). DepEd Order No. 42, s. 2016, also known as the Policy Guidelines on Daily Lesson Preparation for the K to 12 Basic Education Program encourages the use of spiral progression in daily lesson preparation by stating that "teachers shall ensure that learning competencies are spiraled across grade levels to provide for the progression and continuity for learning." This means that teachers should plan their lessons in such a way that they revisit and build on previously learned concepts to promote understanding and retention of the subject matter (Tirol, 2022). Furthermore, DepEd Order No. 8, s. 2015, also known as the Policy Guidelines on Classroom Assessment for the K to 12 Basic Education Program, emphasizes the importance of assessing students' understanding and retention of previously learned concepts.

The degree of student participation in the spiral progression approach to mathematics and the student's academic success in the discussion are significantly correlated. This indicates that when the teacher explains the process well, the students are motivated to learn (Cabansag, 2014). They are also driven to engage in the conversation since it covers the prerequisite ideas for their math course that were taught in earlier grades. As a result, the students' involvement had an impact on their academic success. The students' involvement in peer collaboration and problem-solving activities, however, had an impact beyond their academic performance (L, & Alegre, 2019).

Prior study revealed a link between spiral progression and improved math performance. The student's educational journey describes the path he or she takes as they acquire, apply, and further their knowledge, skills, and understanding in increasingly challenging situations (Resurreccion and Adanza, 2016). Continuity concerns how the educational system organises education and provides students with adequate challenge and opportunity in a recognized curriculum. For instance, in a study by Suh and Moyer-Packenham (2016), spiral progression was found to be more effective than linear progression in teaching fractions to fifth-grade students. Similarly, in a study by Lehtinen et al. (2016), a spiral approach was found to be more effective in teaching algebraic reasoning to students in grades 7-9. There are two basic types of learning retention: long-term retention and short-term retention. Long-term retention refers to the storage of knowledge in long-term memory, where it can last for hours or years. Short-term retention refers to the storage of knowledge in a specific area of the brain, such as the prefrontal lobe, for only a short amount of time (Symons, 2016).

In the context of statistics and probability, some studies have shown that revisiting previously learned concepts can improve learning outcomes. As an instance, Konold et al. (2007), learners who received a refresher on probability concepts at the beginning of a new unit outperformed students who did not receive the refresher. Additionally, in a study by Gazzaniga and Savin-Baden (2012), students who received spaced reinforcement of probability concepts throughout a course demonstrated better learning outcomes than those who received massed reinforcement.

II. DISCUSSION ON LITERATURE

Spiral Progression Approach

Republic Act 10533 of the Philippines, commonly referred to as the "Act Enhancing the Philippine Basic Education System," not only includes basic education by two years and keeps universal preschool, but also establishes the requirements and regulations that the Department of Education must follow when developing curricula. According to one

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component of this prescription, "the curriculum shall use the spiral progression approach to ensure mastery of knowledge and skills after each level."

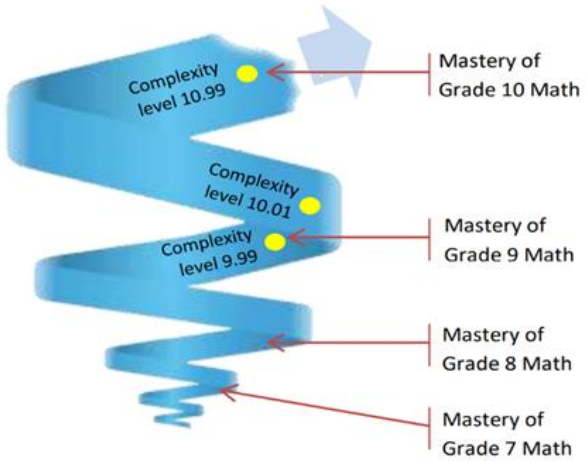
Furthermore, the spiral curriculum combines a number of research-based cognitive sciences techniques that have been related to better individual student performance (ERIC - ED538282 - The Spiral Curriculum. Research Into Practice, Education Partnerships, Inc., 2012-Mar, n.d.). The advantages of spiral progression and spiral curriculum. Spiral curriculum refers to the teaching of a number of subjects that are repeated over the years beginning in the primary grades (Tirol, 2021). A greater grasp of the layers below is what it seeks to accomplish. The spiral progression method was influenced by Bruner's Spiral curriculum concept. The following are some of the expected advantages of this approach: (1) it aids in learning reinforcement; (2) it permits a logical development from simple to complicated ideas; (3) it enables students to apply prior knowledge to new situations and later subjects; and (4) it aids learners. Take notice of the relationships among the different content standards (Diwa, 2018).

The strategy offers numerous chances for students and instructors to become proficient as they are exposed to the same material over the course of the subject. The advantages of the curriculum become more apparent in later years as everything they have learned is skillfully woven together to produce a more comprehensive understanding (Coelho & Moles, 2016). The spiral approach, when used as intended, is successful for all students, even those learners who struggle (Everyday Mathematics, nd). Learning challenges can be handled when the necessary concepts are discovered later in the spiral, the early phases and interventions can still be used (Tinapay et al., 2021).

Bruner's spiral curriculum is a teaching method in which the same subjects are revisited frequently throughout a student's educational journey. Bruner proposed human cognition may be divided into three levels: Enactive, which involves manipulating and interacting with objects, Iconic, which involves engaging in object manipulation and interaction, and Symbolic, which involves influencing visual representations of real-world objects or occurrences. Consistency aims to rovide a predictable educational environment where learners are developed and challenged. Using a spiral progression strategy is therefore one way to put a spiral curriculum into practice (Quintos et al., 2022).

Additionally, the spiral progression approach requires the interdisciplinary integration and cohesion of knowledge, filling the gaps left by the compartmentalized approach (Aquino, 2015; Corpuz & Salandanan, 2015). There are numerous opportunities for creating themes that integrate various subjects and let students make connections between them. Spiral progression effectively captures the crucial idea of cumulative learning (Lee, 2012).

The K–12 curriculum is structured using a spiral progression approach for the following reasons: it prevents incoherence between educational levels, reduces overlap and "jumping" arrangements of topics in different levels, provides the framework for continuity and consistency, encourages a learner-centered approach, emphasizes formative and authentic assessment, allows for flexible content sequencing per quarter, and clarifies misconceptions (Cabansag, 2014; Resurreccion & Adanza, 2015; Tan, 2012).



Mastery

If a learner doesn't succeed in passing the test, they are given additional resources for studying and learning the material. They are again evaluated after that. After the learners have mastered the material, this cycle will be repeated before moving on to the following unit (Hussain, 2016).

Thus, students are not moved until they reach the next learning target unless they show mastery of the most recent one. Curriculum for mastery learning is often composed of distinct subjects that all students begin learning about at the same time (Tirol, 2021). When a student doesn't understand a concept, they receive additional instruction until they do. Early topic masters engaged in extracurricular activities until the remaining class members were ready to move forward. Many aspects of effective tutoring and the autonomous functionality found in top students are included in mastery learning (Tirol, 2022).

Behaviorism concepts of operant conditioning are the origins of the mastery learning idea. According to the principle of operant conditioning, learning occurs when a link is created between a stimulus and a response (Skinner, 1984). The behavior theory claims that mastery learning focuses on external activities that are visible and observable (Baum, 2005). Small discrete lessons that progress logically make up the material that will be taught until it is mastered. Before moving on to the next discussion, learners must be capable of explicitly display their knowledge about the material in each lesson in order to demonstrate mastery of that lesson (Anderson, 2000).

Cyclical

Cyclical learning is a technique that involves learning and relearning information repeatedly over time in order to improve retention and recall. One study discovered that, when compared to traditional massed learning, this technique resulted in greater long-term retention and faster recall in a variety of domains, including vocabulary, grammar, and math (Kornell & Bjork, 2013)

Cyclical learning has also been shown to be effective in educational settings. One study looked at the use of cyclical learning in a high school biology class, where students were given multiple opportunities to review and practice material in a cyclical manner. The findings revealed that students who used the cyclical learning approach outperformed their peers on exams and retained the material better over time (Cioffi & Pugh, 2016). The underlying mechanisms that make cyclical learning effective have also been studied. People with greater stylistic versatility may be better ability to execute successfully in a broader variety of circumstances compared to those who are only capable of using a few different problem-solving and learning techniques (Sreenidhii, et al., 2017).

Academic performance and learning attitudes of students were improved by the students' preferred learning styles and the course syllabus and instruction. The purpose of education is to create and spread information so that pupils can effectively move into adulthood. To create and implement effective and efficient teaching and educational techniques and methods, the teaching community needs to be aware of the preferences of the students' preferred learning styles (Sreenidhii, et al., 2017).

Increasing-Depth

In his book The Process of Education, Jerome Bruner advocated for a sequence of learning stages that allows learners to assimilate material in increasing detail. He advocated for learning through inquiry and opposed the idea that kids should be forced to memorize a lot of facts. He observed education as a process that begins with simple ideas and gradually broadens through repeated exposure. As a result, we revisit and construct in a spiral rather than continuously moving forward in a linear fashion. We can solidify the knowledge's foundations by reviewing the material once more, and then, at each stage, add more depth (Jarmy, n.d.).

Developing students' conceptualizations of important course information is essential to enhancing the depth and breadth of learning. Instructors may work together to provide chances to enhance depth and breadth in a variety of ways, including by stimulate pupils' interest, involve them through the learning process, and Give them options (Galindo, 2023).

According to Beghetto, 2004; Liu et al. 2012, engaging students in their own learning is one way to increase depth and breadth. According to research, when learners take an active role in their learning process, they are more likely to feel engaged in class, perform better on assessments, and retain knowledge for longer.Bain (2004) and Wolters (1998) Instructors should include freedom of choice in their pedagogical toolkit if they want to increase depth and breadth (Tinapay et al., 2023). Students are more likely to learn if they believe they are choosing to do so, or at the very least, choosing something about how they learn (Tinapay & Tirol, 2021).

Reinforcement

The uplifting reinforcement theory was put forth by BF Skinner and his associates. It asserts that a person's behavior is influenced by the outcomes of that behavior. It is founded on the "law of effect," which states that behaviors that produce favorable outcomes are more likely to be repeated than behaviors that produce unfavorable outcomes.

An individual's internal state, or their inner feelings and motivations, are disregarded by Skinner's Reinforcement Theory of Motivation. What happens after a single act is the sole focus of this theory. Thus, according to Skinner, the organization's external environment must be planned effectively and favorably in order to inspire learners. This theory is an effective tool for analyzing how people's behavior is managed. However, it does not focus on what motivates people to act in certain ways.

Consolidation

Consolidation theory makes a transitory, easily forgotten memory into a more lasting one. Retroactive interference, or the observation that newly learned information is susceptible to distractions for some time after training, was initially proposed as an explanation. Consolidation was made easier by the recollection impairment facts, especially those that were presented in earlier publications. The most significant consolidation-related finding was that recent memories are more susceptible to injury or illness than distant ones (Kumar, 2022).

All organisms engaging in recollection-intensive activities for extended periods of time experience the general process of recollection retention via synaptic mechanisms. When discussing synaptic consolidation, prolonged recollection is primarily a permanent memory. The synaptic arrangement is finished much more quickly than system integration. The "rapid" type of consolidation, known as synaptic retention, occurs minutes to hours after memory formation or training. Another name for this phase is the initial consolidation. Synaptic integration and the growth of long-term memory are interfered with, but memories start to become resistant to these interferences as soon as six hours after learning (Kumar, 2022).

Memory consolidation is the process by internal representations that are influenced by experience and neurological bases for those representations change over time. It is believed that this process involves neuron and cell changes in brain circuits where memories have been inherited, resulting in repeated reactivation during wakefulness and sleep as well as redirection of memory to other locations. This starts by disseminating information and coupling it with new information. Let us sum up what you've learned so far. This show you a picture of what we know today about the time course in consolidation and how our brain structure underlies and shapes Long Term memory, as well as gaps in those areas. (Dubai et al., 2015).

Remembering

Remembering is the ability to intentionally think back or reflect on previous experiences, knowledge and events. You have to be able to retain relevant information if you want to learn. By contrast, you will not be able to avail yourself of your prior knowledge, exercises and training. Endel Tulving

asserts that remembering and knowing are two different concepts. The recall method, recognition method, and savings method are techniques for measuring memory (*Psychology*, n.d.).

Over a longer period of time, repeat the material and review it. In the 19th century psychologist Hermann Ebbinghaus argued that our momentary memories lead to complete retention of information. You can remember about 44% of what you were reading after an hour, though. To deal with this, use space repetition. To prevent your memory from getting worse over time, review your materials occasionally (Study International Stuff, 2017). Teachers of mathematics must assist learners in fully comprehending word problems in order for them to solve them. With such a low level of reading competence, inspiring students to improve their problem-solving skills will be challenging. Additionally, learners' difficulties with language and vocabulary stem from a lack of knowledge of arithmetic education as well as the capacity to participate in discussions about various math topics (Valencia, A.et al., 2023).

Rehearsal

There are three possible explanations for why learning strategies had a significant impact on the academic success of students in experimental groups who practiced using learning strategies daily at home. The ability to visualize the day's activities was made possible by rehearsal through learning strategies; knowledge was not exactly rehearsed through these means, and the strategies also displayed the students' own meaning and way of thinking. Students' motivation as a result of incorporating a new method into their learning style is the second factor explaining why learning strategies had a significant impact on their academic success in experimental groups.

The utilization of learning strategies was emphasized to the students, who were told that doing so would help them better understand the material and raise their level of awareness. By practicing subjects with learning strategies, students may have increased their motivation to learn. The constructivism approach, which serves as the foundation for teaching and employing learning strategies, would be the final justification. Constructivism takes a holistic approach to teaching and learning. Students must employ a range of learning strategies in their activities and to complete their assigned tasks, regardless of how the teaching-learning process is set up (Dogan, p. 2015)

The importance of repetition is especially evident in memorization, as memorization only works if information is repeated frequently. The same phenomenon is observed in motor learning, where practice is required to perfect a learned skill, such as typing, playing the piano, or scoring a field goal. Repetition is necessary to anchor working memory in a long-term form (Klemm, 2014).

Retrieval

Confidence of the ability to think, and belief that memory comes back when self-pressure has been removed, are arousal factors for recalling. (Klemm, 2014).

Numerous initial retrieval tasks have been used to replicate the advantages of retrieval practice; these effects are long-lasting and support transfer, inference, and knowledge application. For students of almost all ages and skill levels, retrieval practice has been shown to improve learning of a wide range of materials, and the effects have been established in educational settings with real course materials (Karpicke, 2017). No matter how well students performed on practice tests, how much they enjoyed the activity, or how confident they were in its efficacy, retrieval practice with feedback increased fact retention more than reading did. Retrieval practice is more effective when feedback is provided, perhaps in part by confirming answers that were given with a lack of confidence but, more importantly, by enabling students to fix their mistakes (Leggett, 2016).

The results showed that using paraphrasing helped students remember vocabulary words. This finding is consistent with the literature because it highlights the value of paraphrasing and how it affects encoding. The results show that writing new information down enables the brain to deeper than when notes are taken online, to encrypt information. As a result, because it has been encoded more thoroughly, the brain can recall more information (Lichty, 2022).

A technique that will improve and speed up learning is the use of retrieval practice, when you recall content. Applying what you already know and recalling facts is far more efficient than rereading, making notes, or watching lectures. Long-term learning results from slower, more laborious recall. Fast and simple methods, however, only result in transient learning (Agarwal, n.d.).

Recalling

Recall is a cognitive process that involves retrieving information from one's memory. It is an important aspect of human memory that aids in learning, problem solving, decision making, and many other cognitive functions. Recall has been extensively studied in psychology, neuroscience, and related fields, with a large body of literature devoted to understanding its mechanisms, influencing factors, and relationship to other cognitive processes (Tirol & Tinapay, 2021).

Learning strategies to actively retrieve information from memory are active retrieval exercises as opposed to simply rereading or highlighting study material. Retrieval practice improves learning and memory retention, especially when combined with spaced repetition, according to research (Karpicke & Blunt, 2013) (Roediger III & Butler, 2013). For example, Karpicke and Blunt (2011) found that practicing retrieval of information resulted in compared to simply rereading the material, it is more efficient at protecting information over time. Additionally, spaced repetition - the practice of spacing out study sessions over time - proven to improve memory retention for extended periods of time when combined with retrieval practice (Karpicke & Roediger III, 2014).

Another technique that has been found to improve recall is mental imagery. This entails creating visual or sensory representations of information to be remembered, which can

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aid in the strengthening of neural connections and the retrieval of the information (Schwartz et al., 2019). As an instance of, Wang et al. (2019), participants who created mental images of words to be remembered were better able to recall them compared to participants who simply read the words.

Another effective technique for improving recall is the use of retrieval cues. External stimuli associated with the information to be remembered that can trigger the retrieval of that information are referred to as retrieval cues (Tulving & Pearlstone, 2013).

The effectiveness of retrieval practice has also been found to be influenced by the type of questions used during recall. A study by Liu and colleagues (2020) found that open-ended questions such as: "What have you learnt?" were more effective in enhancing learning and memory than closed-ended questions (e.g., "Did you learn about..."). The authors suggest that open-ended questions promote deeper processing and better consolidation of information. Emotional arousal has also been shown to influence recall. Several studies have found that emotional stimuli can improve memory consolidation and retrieval (McGaugh, 2013).

In addition to these techniques, studies have looked into the use of technology-based interventions to improve recall. Gamification, for instance, has shown its ability to increase recall and engagement in education settings by involving elements of gamification into situations that don't involve games (López-Pernas & Sánchez-Mena, 2017). Virtual reality has also been used to improve recall, with studies showing that virtual reality environments can improve memory retention and retrieval when compared to traditional learning methods (Rizzo et al., 2014; Pallavicini et al., 2020).

Over the last decade, scientists have studied the cognitive processes involved in remembering and how various factors can affect memory retention. One study discovered that practicing information retrieval, such as recalling it from memory, can lead to improved long-term retention (Agarwal et al., 2013)

Further research has looked into how different encoding techniques affect memory retention. According to one study, visual imagery can help with memory recall (Cai et al., 2018). Memory can be influenced by factors other than encoding, such as emotion and context. One study, for example, discovered that emotional arousal can lead to improved memory retention.

One study looked at sleep memory consolidation plays an important role and discovered that people who slept right after learning new information had better recall than those who stayed awake (Diekelmann & Born, 2013). This suggests that sleep is necessary for memory consolidation and emphasizes the potential benefits of taking breaks and resting after learning.

Memory performance has also been shown to improve when mnemonic strategies such as imagery or association are used. A study on the use of imagery in memory training discovered that individuals who used imagery techniques outperformed those who did not (Carruthers & Claxton, 2015).

Revisiting

Rather than cramming all the information into a single session, spatial practice benefits from the distribution of study sessions over time, have been the focus of research on revisiting knowledge in mathematics. One study discovered that spaced practice improved both short-term and long-term mathematics problem-solving skills, with participants who spaced their practice performing better on a post-test given one week after the initial training session (Gomez-Paloma & Ponsoda, 2015). Another study discovered that spaced practice increased mathematical knowledge transfer to new problem-solving contexts, indicating that this technique can help learners apply their knowledge more flexibly (Rohrer & Taylor, 2016).

Furthermore, research has looked into the role of interleaving in mathematics learning, which involves combining different types of problems rather than practicing one type at a time. Interleaving improved performance on a mathematics problem-solving task and led to improved material storage over a longer period, according to one study, when compared to a blocked practice condition in which participants practiced one type of problem at a time (Rohrer & Taylor, 2016)

Self-explanation in mathematics learning, which involves explaining how to solve a problem or concept in one's own words, has also been studied. According to one study, self-explanation improved performance on a mathematics problem-solving task and resulted in better long-term retention of the material when compared to a control group that only received feedback on their responses (Chi, et al., 2014). Another study discovered that self-explanation increased learners' ability to apply their mathematical knowledge to new problem types while also increasing their conceptual understanding of the material (Renkl et al., 2014). Computer technologies have the potential to revolutionize education by expanding the options available to instructors and fostering closer collaboration among students, their peers, and subject matter experts (Pinote,D.et al. 2023).

Attention

Based on a neurological standpoint, Norton and Pettegrew (1979), and Penner (1984) described attention to be processes that are cognitive and receptive stimuli that cause arousal that enter consciousness. These procedures entail "(a) orienting oneself to sensory experiences, (b) identifying indications of focused (conscious) processing, and (c) remaining watchful or awareness (Rosegard & Wilson, 2013).

The "cue utilization hypothesis" explains that arousal and performance have an inverted U-shape relationship that depends with particular attention. The basic tenet of the idea is that arousal is inversely associated with attentional or cue utilization time. While attention will widen or the number of cues that can be processed will be constrained as arousal increases, attention will expand as arousal decreases expanding or widening the range of cues. This can either be advantageous or disadvantageous, depending on the circumstance. Learning suffers when attention is insufficient or inappropriate (Rosegard & Wilson, 2013).

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Situational interest is a fleeting emotional reaction to a stimulus coming from a particular thing, place, thing, activity, or event that concentrates someone's attention. Individual interest is a more persistent predisposition that develops over time as a result of ongoing cognitive and affective processing of a particular subject or activity. The ability to hold students' attention is more closely linked to situational interest (Rosegard & Wilson, 2013).

Consciousness's characteristics, self-awareness, and the vast majority of hypotheses about the mind are all closely related to attention as a cognitive process in philosophy. The purpose of attention can either be the active processing of environmental stimuli via sensors or the generation of associational data along with possible responses through continuing mental activity. Several research have examined the effects of attention on memory recall from numerous perspectives, including the impact of split attention, focused attention to improve remember, attention and word frequency, and cognitive variables impacting free recall and cued recall (Alduais & Almukhaizeem, 2015).

Attention is a state of mental alertness and a focusing activity. A person is more likely to recognize the characteristics of fit for purpose when they focus their attention on a specific stimulus and the consciousness is implanted with a feature that is paid attention to. As a result, choosing and learning are made simpler. The mind does not go into unnecessary details when processing the information. Keeping your attention where it belongs is the idea that stands out in this paragraph (Cicekci & Sadik, 2019). The reinforcement of a behavior draws attention, according to the behavioral learning theory. Operant conditioning necessitates significant stimulation, whereas classical conditioning allows for cautious stimulus control. The process of processing information starts with attention, in accordance with theory of information processing. The sensory recall, which is the first component of the mental process, receives information from the outside world first processing device. However, the sensory memory has a very short retention time for information in order to learn. The short-term memory must receive and process information. The process that determines which data is sent to the short-term memory is under scrutiny. The initial prerequisite for learning through observation is to pay close attention to the chosen model (Tinapay & Tirol, 2021).

Many people have suggested that variations in attention are the basis for changes in human memory (Nelson & Fivush, 2004; Posner & Rothbart, 2007). However, attention is not a single activity; rather, it is a collection of processes. Our ability to focus on a particular activity or input while ignoring distracting information is known as selective attention. Six years old to adolescence, there is a noticeable improvement in selective attention (Vakil et al., 2009). Sustained attention refers to the ability to focus for long periods of time. Divided attention, commonly referred to as multitasking, is the ability to move our focus between work or outside stimuli, and it improves with age (Carlson et al., 2013). Students are more likely to participate and concentrate in class when they believe they can master the content and have control over their education (Tirol, 2023).

III. Conclusion

A spiral progression approach involves revisiting and building upon previously learned concepts in a cyclical manner. Instead of linearly progressing through a subject, this approach emphasizes repeated exposure to foundational knowledge while introducing new and more complex ideas over time. By revisiting earlier material and connecting it to new concepts, students are encouraged to deepen their understanding, make connections, and reinforce their knowledge. In the context of statistics and probability education, a spiral progression approach could involve introducing fundamental concepts such as data analysis, probability theory, and statistical inference at a basic level. As students' progress, the approach would then revisit and expand upon these concepts, delving into more advanced topics like regression analysis, hypothesis testing, or Bayesian statistics. This cyclic pattern allows students to continuously engage with the material, reinforcing their understanding and addressing any gaps in knowledge. The spiral progression approach recognizes that learning is an iterative process, and repetition plays a crucial role in knowledge retention. By systematically revisiting and building upon previously learned material, students may develop a more comprehensive and interconnected understanding of statistics and probability concepts, ultimately enhancing their retention and application of these skills.

It is crucial to note, however, that the specific findings, outcomes, and implications of the "Enhancing Students' Retention in Statistics and Probability through the Spiral Progression Approach" study remain unknown without access to the actual research. For a comprehensive understanding of this approach and its effects on student retention, it is advisable to refer to the study itself or related literature in the field.

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