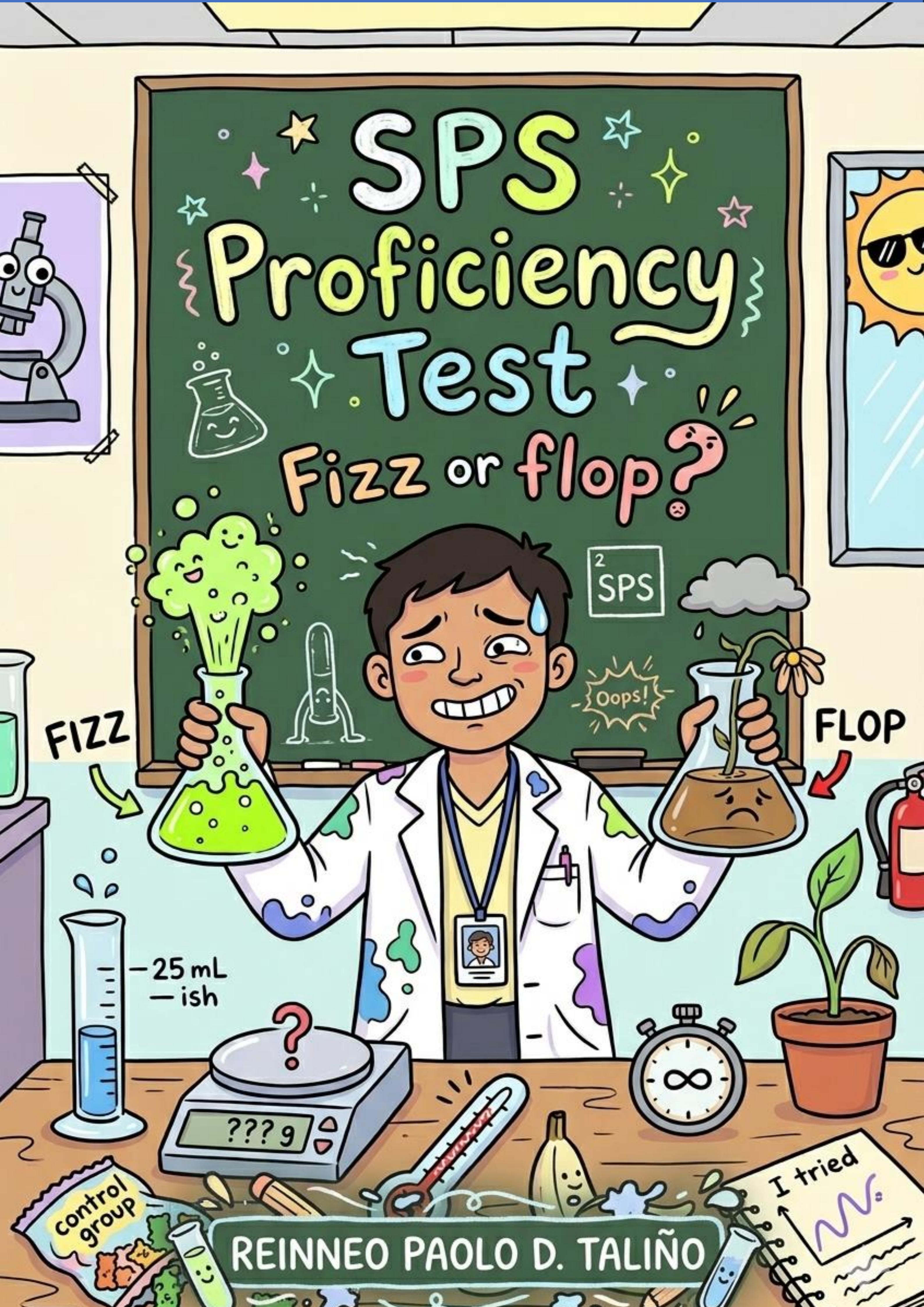
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REINNEO PAOLO D. TALIÑO

Copyright Page

SPS Proficiency Test: Fizz or Flop?

EduHeart

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To my nephews—Lyle, Nyro, and Primo—and my niece—Louise—this book is for your future. I hope that when you are old enough to understand, you will know that I worked hard so that the teachers who guide you will be better prepared. May you always be curious, ask questions, and never stop exploring.

To my colleagues at Pangasinan State University – Bayambang Campus who listened to me talk about science process skills for months—thank you for your patience, your questions, and your encouragement.

To the EduHeart Knowledge Network and Publishing Team—thank you for seeing value in this project and bringing it to publication.

And to my students, past and present—you taught me that a test is only useful if it helps someone learn. I hope this one does.

The Author

Dedication

To my Papa Jun and Mama Belen.

To myself ten years ago—drowning, yet dreaming.

Look at us now.

Foreword

Teacher education in the Philippines stands at a critical juncture. The shift towards inquiry-based learning and the K-12 curriculum demands science teachers who do not merely know facts but can actually DO science. This is easier said than done.

For years, I have watched pre-service science teachers enter their practice teaching with impressive grades across different areas of science, yet show visible discomfort when handling simple lab equipment. They can recite the steps of the scientific method but freeze when a student asks an unexpected question= about their experiment. The gap between knowing science and teaching science remains wide.

Dr. Reinneo Paolo D. Taliño's Science Process Skills Test addresses this gap head-on. This is not another multiple-choice test of science facts. It is a carefully validated instrument that reveals what future teachers can actually do—observe, measure, predict, design experiments, and interpret messy data.

What I appreciate most about this work is its grounding in the Filipino context. Too many assessment tools imported from Western contexts carry implicit assumptions about access to laboratories, availability of equipment, and cultural familiarity. This test uses examples from chemistry labs at Philippine universities. It asks questions about materials teachers might actually have. It respects our reality while pushing for higher standards.

I recommend this book to every teacher educator who has ever wondered whether their students are truly ready to teach science. The answers are in these pages.

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Preface

"What do we really know about the people we are training to teach science?"

That question has followed me for years. And every time I ask it, I think about a simple truth from the laboratory: things either fizz or they flop.

Fizz is when it works. The reaction happens. The measurement is accurate. The hypothesis holds. Flop is when it does not. The liquid spills. The numbers do not add up. The experiment gives you nothing but a mess and a question mark.

Here is the thing about fizz and flop. You learn more from the flops. A successful experiment tells you that your method worked. A failed one forces you to ask why. Did I measure wrong? Did I forget to control a variable? Did I misunderstand the problem? That questioning is the heart of science. Not getting it right the first time. But being curious enough to try again.

Now think about how we train future science teachers. We give them lectures. We test their memory. We ask them to recite the scientific method. But do we give them enough chances to fizz and flop on their own? Do we watch them struggle with a graduated cylinder and say, "Figure it out"? Or do we hand them the answer key?

Most of the time, we hand them the answer key. And that is a problem. Because a teacher who has never flopped will not know how to help a student who does.

This test is not about catching who flops. It is about finding out who is ready to teach and who still needs more time at the bench. The questions are simple. Observe. Classify. Measure. Infer. Predict. Control variables. Interpret data. Formulate hypotheses. Experiment. Model. These are not chemistry skills. They are science skills. Biology. Physics. Earth science. Any lab, any field, any question worth asking.

The test was built carefully. Experts reviewed it. Students pilot-tested it. It went through revision after revision. Not because I wanted it to be perfect, but because a test that gives wrong information is worse than no test at all.

So here it is. Fifty-six questions. Ninety minutes. No tricks. No foreign examples that make no sense here. Just real science tasks in familiar contexts.

Use it to see your students clearly. Celebrate the fizz. Learn from the flop. And then teach better.

Reinneo Paolo D. Taliño
Bayambang, Pangasinan

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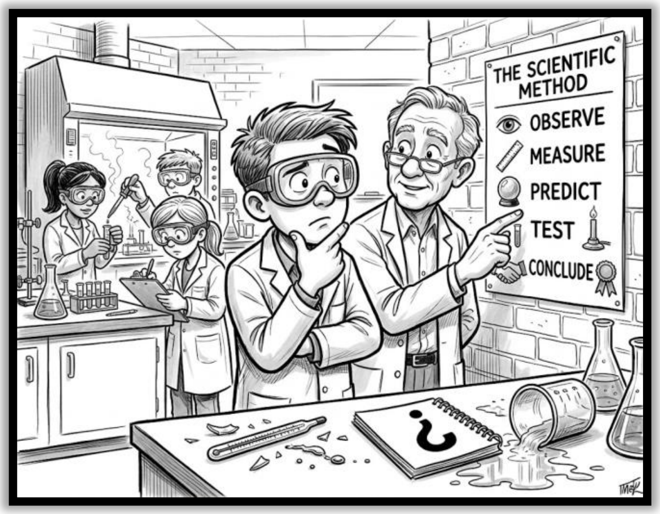
Introduction

What Future Science Teachers Need

"Copying definitions won't make bubbles fizz. Neither will it make a good science teacher."



Think about a chemistry teacher standing in front of a class. The teacher asks students to find out which of two white powders reacts faster with vinegar. A student raises a hand and asks, "How do we know which one is which?" The teacher does not give the answer. Instead, the teacher says, "What could you do to find out?" The students then design a simple experiment. They measure equal amounts of each powder. They add the same volume of vinegar. They time how long it takes for bubbles to stop. This is good teaching. But it only works if the teacher knows how to do these things themselves. The teacher must know how to observe closely, measure accurately, identify what to change and what to keep the same, and interpret the results. These abilities are called **Science Process Skills (SPS)**.

In many schools today, science teaching still relies heavily on lectures and memorization. Students copy definitions from the board. They answer questions at the end of the chapter. But they rarely touch lab equipment. This is especially true in the Philippines, where many public schools lack functioning laboratories (Delgado & Villacero, 2022). When labs do exist, teachers often use them only for demonstrations. Students watch. They do not actually do the work themselves (Rogayan, 2022). Why does this happen? One major reason is that many science teachers themselves never learned process skills well during their own training. In their college years, they may have spent more time memorizing chemical formulas than measuring reaction rates or designing experiments (Wong et al., 2022). A teacher who has never struggled to control variables in a lab will find it hard to teach that skill to students.

Studies from many countries confirm the importance of hands-on practice. In Tanzania, students who used computer simulations and active lab activities improved their science process skills much more than students who only read textbooks (Beichumila et al., 2022). In Ethiopia, guided inquiry labs helped students develop skills in experimental design and data interpretation, with a very strong effect (Chengere et al., 2025). In Malaysia, even young students showed clear progress when teachers used inquiry-based methods (Baharom et al., 2020). But these studies also point to a serious challenge.

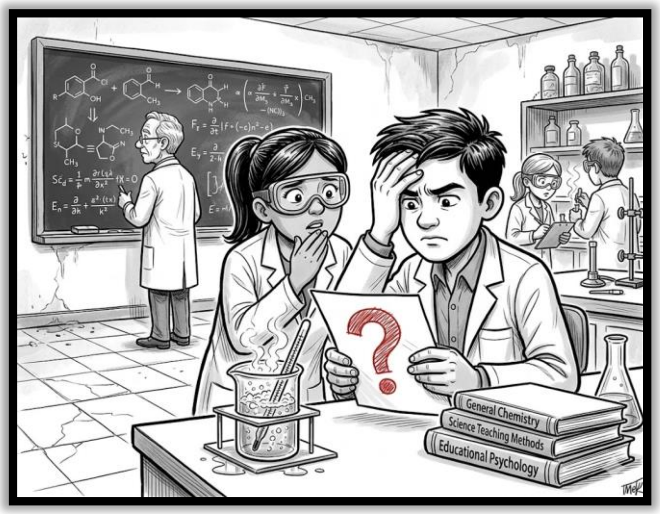
Teachers themselves need training to use these methods effectively. A teacher who does not understand how to formulate a hypothesis or operationally define a variable will struggle to guide students through an inquiry lesson (Qodriyani et al., 2020).

This brings us to teacher education. If we want future science teachers to be confident and capable, we must first make sure they have strong science process skills themselves. They need to practice observing changes in a chemical reaction. They need to measure volumes accurately using a graduated cylinder. They need to make predictions based on patterns in data. They need to design fair experiments, control variables, and interpret their results. These skills are not automatic. They develop through repeated, hands-on practice (Kurniawati, 2021). A lecture on the scientific method is simply not enough. A teacher-in-training must actually *do* the method—many times, in many different contexts.

This is where a test like the Science Process Skills Test (SPST) becomes useful. It gives teacher educators a clear picture of what their students can and cannot do. For example, a student might score well on measuring but poorly on formulating hypotheses. That tells the instructor where to focus more lab activities. It also helps the student see their own gaps. Many pre-service teachers overestimate their skills. A good assessment can show them the truth in a helpful, non-threatening way (Çoruhlu et al., 2023). Science education is not just about producing future scientists. It is about producing citizens who can think critically, solve problems, and make decisions based on evidence. But this starts with teachers. A teacher who knows how to ask good questions, design simple experiments, and interpret messy data will pass those habits on to hundreds of students over a career. That is why building science process skills in teacher education matters so much. It is an investment not just in one person, but in every student that person will ever teach.

A Missing Tool for Filipino Classrooms

"You can't find out if a future teacher can measure a liquid by asking about a snow gauge. That's like checking a fisherman's skill by asking him to ride a camel."



Imagine a chemistry laboratory in a teacher education college in the Philippines. A pre-service science teacher has just finished a test on science process skills. The test asked questions about observing, measuring, and experimenting. But the questions used examples that the student did not recognize. One question talked about using a snow gauge to measure precipitation. Another asked about designing an experiment with a centrifuge that the student had never seen. The student tried their best, but they felt lost. After the test, they thought, "This test was not made for me. It was made for students in another country, with different equipment and different experiences."

This situation happens often in the Philippines. Many science tests used in teacher education programs are developed in other countries. They may be valid and reliable in those places. But they are not always a good fit for Filipino students. The language may be too difficult. The examples may refer to materials or equipment not commonly found in Philippine schools. The cultural context may be unfamiliar (Mushani, 2021).

Why is this a problem? Because a test that does not fit the students will not give accurate results. If the test uses unfamiliar examples, a student might get a low score even if they actually have good science process skills. On the other hand, a student might guess correctly by chance. The test fails to measure what it is supposed to measure. For teacher educators, this is a serious issue. They need to know which skills their students truly have and which skills still need work. Without an accurate test, they cannot plan effective lessons or lab activities (Kurniawati, 2021).

The situation is even more urgent for Bachelor of Secondary Education (BSEd) Science students. These students will become science teachers. If their own skills are not assessed correctly, their training may miss important gaps. A future teacher who cannot accurately measure liquid volumes or control variables in an experiment will struggle to teach those skills to high school students. But without a good test, neither the student nor the instructor will know there is a problem (Gizaw & Sota, 2023).

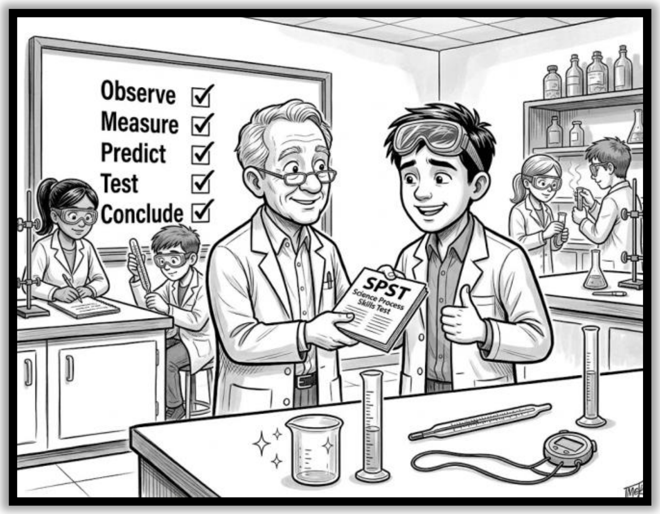
here are other challenges too. Many existing science process skills tests are very long. Some have 100 or more items. Busy teacher education programs cannot easily fit such a long test into their schedule. Other tests focus only on basic skills, like observing and classifying. They ignore integrated skills, such as formulating hypotheses and interpreting data. But integrated skills are exactly what future teachers need most when guiding students through open-ended lab investigations (Çoruhlu et al., 2023).

Some tests are designed for young children, not for college students. The questions may be too simple. They do not challenge future teachers. Other tests are designed for professional scientists. They assume access to advanced laboratory equipment that is not available in most Philippine teacher education institutions (Delgado & Villacero, 2022). What is missing is a test that is just right for Filipino BSEd Science students. It should use examples from a typical chemistry laboratory in a Philippine university. It should cover both basic and integrated skills. It should be the right length—not too short, not too long. And it should be validated, meaning experts have checked that it actually measures what it claims to measure.

This gap in available tools is what motivated the development of the Science Process Skills Test (SPST) for BSEd Science students. The test was created specifically for Filipino pre-service science teachers. The questions are set in familiar contexts, such as measuring the temperature of a chemical reaction, classifying local materials, or designing a simple experiment using common lab equipment, such as beakers, graduated cylinders, and balances. The test was reviewed by Filipino experts in science education. It was pilot-tested with Filipino students who are similar to the target group. The result is a test that fits the local context, respects the realities of Philippine science classrooms, and gives teacher educators useful, trustworthy information about their students' science process skills.

A Test You Can Use Right Away

"A good test doesn't just give a score. It tells a future teacher what they actually know—and what they still need to learn."



Imagine you are a teacher educator. You walk into a chemistry laboratory with fifteen pre-service science teachers. You want to know how well they can observe, measure, predict, and design experiments. You know that these skills are essential for their future classrooms. But you do not have a good test to give them. The tests you find online are either too long, too short, too easy, or designed for students in other countries. You could try to make your own test. But that takes weeks of work. You would need to write questions, check them with experts, test them with students, and analyze the results. You have teaching to do. You have lessons to plan. You have lab activities to prepare. You do not have that much time.

This book is written for people in exactly that situation. The purpose of this book is simple: to give you a **ready-to-use, validated instrument** for measuring science process skills among Bachelor of Secondary Education (BSEd) Science students. You do not need to develop your own test. You do not need to spend months validating it. The work has already been done for you.

The test inside this book is called the Science Process Skills Test (SPST). It has 56 multiple-choice questions. It covers both basic skills (observing, classifying, measuring, communicating, inferring, predicting, using numbers, using space-time relationships) and integrated skills (identifying and controlling variables, operationally defining variables, formulating hypotheses, interpreting data, experimenting, formulating models). Every question is set in a familiar context—usually a chemistry laboratory or a typical science classroom in the Philippines. Students will see questions about measuring liquid volumes, timing chemical reactions, classifying local materials, designing fair tests using common equipment such as beakers and graduated cylinders, and interpreting data from simple graphs.

Why can you trust this test? Because it has been validated. The development process followed established standards for educational measurement. A panel of seven Filipino science education experts reviewed every question. They used a Content Validity Index (CVI) to rate each item. The results were excellent. The Scale-level Content Validity Index (S-CVI) for Universal Agreement was 0.9714, and for the Averaging Method it was 0.9959. These numbers mean that the experts strongly agreed that the test questions are relevant, clear, and appropriate for BSEd Science students.

The test was also pilot-tested with 30 students who were similar to the target group. The results were analyzed using item difficulty and discrimination indices. Poorly performing items were removed or revised. The final 56-item test showed good internal consistency, with a Kuder-Richardson Formula 20 reliability coefficient of 0.843. This means that the test gives stable, dependable scores. You can use it with confidence.

The test takes 90 minutes to complete. That is short enough to fit into a regular class period or a laboratory session. The answer key and scoring guide are included in this book. To calculate a student's mastery level, use this formula: *Mastery Level = (Number of Correct Answers ÷ Maximum Score) × 100*. The book also provides a table for interpreting the scores, from "Very Low" to "Mastered."

Who can use this test? Teacher educators can use it to assess their pre-service science students at the beginning, middle, or end of a program. They can compare results across different cohorts or track improvement over time. Researchers can use it to study how different teaching methods affect science process skills. Program evaluators can use it to check whether a teacher education program is meeting its goals. And pre-service teachers themselves can use it to identify their own strengths and gaps, so they know what to focus on during their training.

You do not need special training to administer this test. Just print the test, give it to your students, and follow the instructions. The scoring is straightforward. The interpretation is clear. Everything you need is right here in this book. No more searching online for tests that do not quite fit. No more making your own from scratch. No more guessing whether your students actually have the skills they need. The Science Process Skills Test is ready. You can start using it today.

SPS Unpacked *(No Lab Coat Required)*

"Facts are nice. But watching metal fizz in acid? That's where the fun starts."

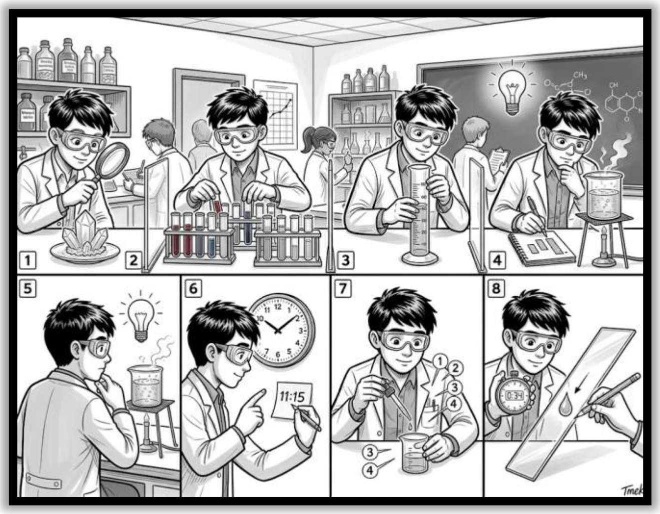
Your teacher assigned a simple task. Find out how fast a certain metal dissolves in acid. But you cannot just look up the answer. You have to figure it out yourself. What do you do? First, you look closely at the metal. Is it shiny or dull? Does it have scratches or pits? You are observing. Next, you take a piece of the metal and drop it into a beaker of acid. You notice bubbles forming. You ask yourself, "Is the metal dissolving faster when the acid is hot or cold?" That thought leads you to infer a possible relationship. Then you decide to test your idea. You prepare two beakers. One with cold acid, one with hot. You use the same amount of metal in each. You time how long the bubbling lasts. This is experimenting. You write down the times. You calculate the average. You draw a simple graph. You tell your classmates what you found. These actions—observing, inferring, experimenting, measuring, calculating, graphing, and explaining—are called science process skills (SPS).

Science process skills are the tools that scientists use to investigate the natural world. They are not facts to memorize. They are actions to perform. Think of them like the steps in a recipe, but more flexible. A good cook does not just read a recipe once. They taste, adjust, and try again. Similarly, a good science student does not just read about an experiment. They observe, measure, predict, test, and interpret. These skills work together. They build on each other. And they improve with practice (Kurniawati, 2021).

There are two main groups of science process skills: basic and integrated. Basic skills are the simpler ones. You usually learn them first. Integrated skills are more advanced. They combine several basic skills to solve a problem or answer a question (Gizaw & Sota, 2023).

The Starter Pack for Lab Work

"You want to design cool experiments? First, learn how to read a thermometer without licking it."



Before you can design a full experiment, you need smaller tools. Think of these tools like the basic strokes a painter learns first. You cannot paint a masterpiece if you cannot hold a brush or mix colors. The same is true in science. Before you can investigate a question, you need to master the **basic science process skills**. There are eight of them. Each one is simple by itself. But together, they form the foundation for everything else.

Let us walk through each skill using a chemistry laboratory as our guide.

a) **Observing** involves using your senses to gather information about objects or events. As noted by Carin (1993, as cited in Kurniawati, 2021), it includes planning, questioning, measuring, and communicating findings. In the chemistry lab, this means noting the color of a liquid, the fizz of a reaction, or the warmth of a beaker. A good observer details specific shapes of crystals or observes that bubbles form faster near the bottom of a beaker. Observing is fundamental in scientific investigations (Kurniawati, 2021).

b) **Classifying** involves grouping objects or events based on similarities and differences (Suman, 2017; Kurniawati, 2021). In a chemistry lab, you might classify chemicals as solids, liquids, or gases, sort test tubes by size or color, or group metals by their reactivity with acid. This organization leads to clearer patterns, such as observing that metals that fizz in acid are gray and shiny, which can spark new questions (Irwanto, 2023).

c) **Measuring** involves comparing physical properties—like length, mass, volume, or temperature—to standard units (Kurniawati, 2021). Tools such as rulers, balances, graduated cylinders, thermometers, and stopwatches are used to provide precise numerical data. For example, instead of saying "the liquid is warm," you would state "the temperature is 45 degrees Celsius." This numerical precision allows for effective comparisons across trials and among different people. In chemistry, measuring is essential: you measure the volume of acid, the mass of solids, and the time for reactions. Without measurement, scientific inquiry would be mere guesswork (Baharom et al., 2020).

d) **Communicating** involves using words, symbols, and visuals to exchange information (NARST, n.d.; Kurniawati, 2021). A well-labeled graph or clear report illustrates your data and findings. Effective communication ensures others understand your methods and results, making science a shared activity. After all, the value of discovery lies in the ability to share it (Kurniawati, 2021).

e) **Inferring** involves explaining observed phenomena by connecting sensory data to prior knowledge (Kurniawati, 2021). Unlike observing, which simply describes what you see, inferring provides explanations. For instance, if you notice bubbles in a beaker, that's an observation; inferring that a gas is produced because some reactions release gas is your interpretation. Inferences are educated guesses based on evidence and go beyond immediate data. In a chemistry lab, you infer things like a new substance forming from a color change or a reaction absorbing heat when the temperature drops. These inferences are testable explanations that contribute to the excitement of science (NARST, n.d.).

f) **Using numbers** means performing mathematical operations such as counting, adding, subtracting, multiplying, and dividing to quantify or analyze data (Kurniawati, 2021). In a chemistry lab, you might count bubbles, sum sample masses, find temperature changes, calculate average reaction times, or determine density by dividing mass by volume. Using numbers effectively transforms raw data into meaningful information; without it, measurements lack significance (Kurniawati, 2021).

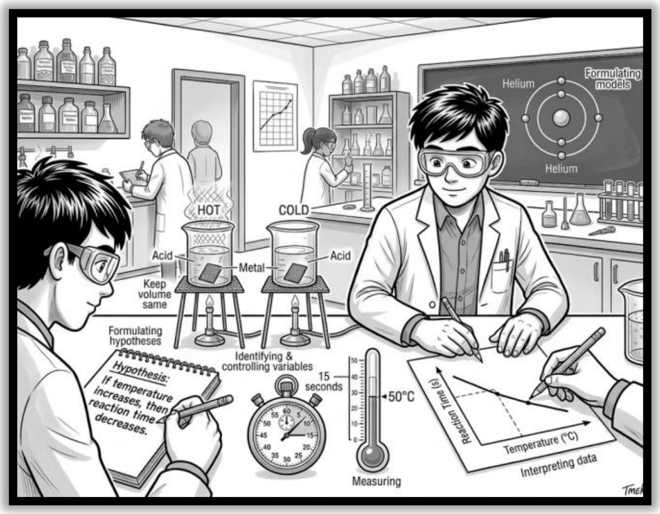
g) **Using space-time relationships** involves observing how objects move or change over time and space (Gizaw & Sota, 2023). In a chemistry lab, you might track a reaction's temperature change every 30 seconds or measure how far a gas bubble rises in one minute. This skill reveals patterns, such as a rapid initial temperature increase that then slows, indicating the reaction rate. Time and space are important to chemists and physicists alike (Çoruhlu et al., 2023).

These eight basic skills are not meant to be learned alone. They work together. You observe a reaction. You measure its temperature every minute. You record the numbers in a table. You look for a pattern. You predict what will happen next. You infer why it happens. Then you communicate your findings to a classmate. Each skill supports the others. And together, they prepare you for more advanced integrated skills—such as designing experiments and testing hypotheses (Wong et al., 2022).

For a future science teacher, mastering these basic skills is not optional. You cannot teach a student how to measure volume if you always guess. You cannot guide a student to make a good inference if your own inferences are shaky. The basic skills are the foundation. Build them well, and everything else becomes easier (Kurniawati, 2021).

Putting Your Starter Pack to Work

"Variables, hypotheses, models—sounds fancy. But really, it's just organized curiosity."



Now that you know the basic tools—observing, classifying, measuring, communicating, inferring, predicting, using numbers, and using space-time relationships—it is time to use them together. This is where the real fun begins. **Integrated science process skills** are the advanced tools. They combine several basic skills into one powerful activity. Think of basic skills as individual bricks. Integrated skills are the walls, the rooms, and the whole building. You need both. But the integrated skills are what let you answer real questions and solve real problems.

There are six integrated science process skills. Each one is essential for doing full scientific investigations. Let us explore them one by one, always with our chemistry laboratory in mind.

a) **Identifying and controlling variables** is crucial in experiments. A variable is anything that can change, with three types: independent (the factor you change), dependent (the result you measure), and controlled (factors you keep constant). For example, if you want to see how temperature affects the rate at which metal dissolves in acid, the temperature is the independent variable, while the time it takes for the metal to stop bubbling is the dependent variable. Controlled variables include the amount of acid, size of the metal piece, type of beaker, and stirring method. Failing to control these can lead to unreliable results, making it essential for fair testing and trustworthy conclusions.

b) **Operationally defining variables** means providing clear, measurable definitions for vague concepts. Kurniawati (2021) notes that this skill establishes specific parameters, facilitating communication about the phenomena being studied. Scientists require precision; for example, to measure "how fast the metal dissolves," you might define it as "the number of seconds from when the metal touches the acid until no more bubbles are visible." Such definitions enable repeatability and clarify terms, turning abstract ideas into concrete measurements. For instance, a "strong acid" can be defined as one with a pH of 2 or lower, while "reaction complete" might be when the temperature returns to room temperature with no bubbles for 10 seconds. These operational definitions eliminate ambiguity and disagreement (Kurniawati, 2021).

c) **Formulating hypotheses** involves creating testable statements that predict the relationship between variables. According to Gizaw and Sota (2023), this process involves suggesting explanations grounded in accurate observations. A good hypothesis is an educated prediction, often in an "if-then" format, such as "If the temperature of the acid increases, then the reaction time will decrease." It should specify a relationship clearly; for instance, "Increasing temperature from 25°C to 50°C will cut the reaction time in half" is much better than a vague statement. Overall, formulating hypotheses transitions curiosity into a structured inquiry (Gizaw & Sota, 2023).

d) **Interpreting data** involves analyzing collected information, typically presented in tables or graphs, to identify patterns, relationships, or trends (Chengere et al., 2025). This process gives meaning to raw numbers, such as observing that reaction times decrease as temperature increases. For example, a graph with temperature on the x-axis and reaction time on the y-axis may show a downward slope, indicating that higher temperatures speed up reactions. However, unexpected patterns, like a sharp drop in reaction time between 20°C and 30°C, may emerge, prompting further investigation of their significance and implications for the hypothesis. In essence, interpreting data is akin to being a detective with numbers.

e) **Experimenting** is a critical skill that evaluates hypotheses through structured investigations (Beichumila et al., 2022). It involves asking questions, stating hypotheses, controlling variables, conducting trials, and interpreting results. Unlike merely following a lab manual, true experimentation requires making decisions about what to change, measure, and how to analyze data. In a chemistry lab, for example, you might compare two catalysts by setting up identical reactions and measuring their speeds. While experimenting can be messy and frustrating, it is ultimately rewarding.

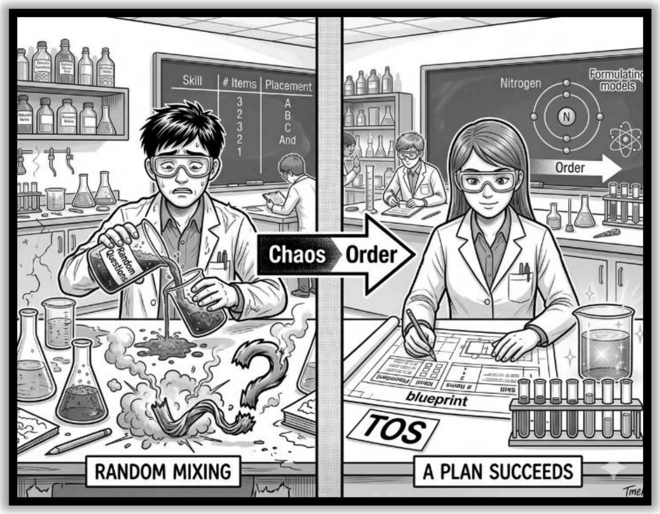
f) **Formulating models** involves creating representations to explain ideas, objects, or processes (Çoruhlu et al., 2023). These can be physical (like a 3D model of a molecule), visual (such as a diagram of an atom), mathematical (like an equation predicting reaction rates), or analogical (comparing a cell to a factory). Models simplify complex concepts for easier understanding and testing, but they have limitations; for instance, a ball-and-stick model depicts atomic arrangement but not actual sizes or electron movement. A good scientist understands both the strengths and limits of their models. In a chemistry lab, a diagram of molecular collisions aids in visualizing interactions that aren't visible, making it more informative than an empty beaker (Çoruhlu et al., 2023).

Why are these integrated skills so important for future science teachers? Because real science is not just about knowing facts. It is about asking questions and finding answers. When you teach a student how to identify variables, you are teaching them to think carefully. When you guide them to formulate a hypothesis, you are teaching them to make predictions based on evidence. When you help them interpret data, you are teaching them to find meaning in numbers. These are not just science skills. They are life skills. And a teacher who has mastered them can pass them on to the next generation (Wong et al., 2022).

Science Process Skills Test (SPST)

Your Blueprint (No Hard Hat Required)

"Random questions make random results. Get a plan."



A test needs a plan. Random questions will not work—that is like mixing random chemicals and hoping for gold. A Table of Specifications (TOS) provides that plan. It shows which skill each question tests, how many questions to write, and where to place them (Kurniawati, 2021).

The TOS for the SPST was built in a few simple steps. First, the author listed the 14 science process skills—eight basic and six integrated—based on the literature. Next, a clear definition was written for each skill, and five measurable competencies were defined for each. Then 70 draft items were developed, each matched to a competency and placed in a TOS.

Seven Filipino science education experts reviewed the TOS and the questions. After pilot testing and item analysis, weak items were removed or revised. The final TOS contains 56 items: 31 for basic skills and 25 for integrated skills.

Table 1 presents the original Table of Specifications (TOS) developed for the Science Process Skills Test. This version contains 70 items—40 for basic skills and 30 for integrated skills. It represents the initial blueprint before pilot testing and item analysis.

The original TOS is presented for transparency. It shows how the test was planned from the start. After expert review and pilot testing, the final test was reduced to 56 items. Some items were removed or revised based on difficulty and discrimination indices. However, the original TOS remains useful. It shows the full range of skills originally targeted and the careful planning behind the instrument.

Table 1
Table of Specifications (TOS) for Science Process Skills

Science Process Skill	Definition	Competency	Item Placement
Observing	The process of gathering information about objects and events using the senses (eye, ear, skin, nose, tongue). It also refers to data gathering using instruments that aid the senses, such as telescopes, microscopes, and medical devices. It constitutes a fundamental scientific process for examining natural phenomena (Kurniawati, 2021). Activities include identifying characteristics, detecting changes, and organizing data, with Carin (1993, as cited in Kurniawati, 2021) emphasizing components such as planning, unbiased sensing, questioning, measurement, noting similarities/differences, tracking changes, and communicating findings.	Plan controlled observations by identifying key variables to ensure fair testing in comparative environmental studies.	1
		Utilize contrast-enhancing techniques to make cellular structures visible when using microscopes.	2
		Apply multiple sensory observations (sight, touch, taste) safely to distinguish between substances based on properties.	3
		Conduct repeated measurements over time to track changes and reduce bias in plant growth experiments.	4
		Monitor long-term changes through repeated systematic observations of natural phenomena.	5
Classifying	involves grouping or ordering objects or events into categories. The basis of the grouping or categorization is their similarities, differences, relationships in characteristics, or defined criteria (Suman, 2017; Kurniawati, 2021). This skill involves organizing	Select a clear and observable physical characteristic to create distinct groups when sorting biological specimens.	6
		Order objects based on a defined physical property by analyzing comparative test data to create a sequence.	7
		Apply a dichotomous key based on observable traits to categorize biological specimens into predefined groups.	8

	entities according to shared properties, such as sorting rocks by grain size or hardness (NARST, n.d.). This skill enables systematic organization of information to reveal patterns and relationships essential for scientific analysis.	Determine the underlying defining criteria used to classify objects into broad taxonomic groups.	9
		Evaluate classification systems based on the relevance and fundamental nature of the criteria used to determine which system better reveals functional relationships.	10
Measuring	entails comparing physical properties against standardized units to obtain quantitative data (Kurniawati, 2021). It requires selecting appropriate tools (e.g., rulers, scales) and units (e.g., meters, grams) for tasks such as determining length, volume, mass, temperature, or time, ensuring accuracy in empirical investigations. Its effectiveness depends on proficiency with measuring tools and accurate calculations (Suman, 2017). Measuring employs standard or nonstandard estimates to describe dimensions, such as using a meter stick to quantify a table's length (NARST, n.d.).	Select appropriate tools and standardized units to obtain quantitative data for a given physical property and object scale.	11
		Record quantitative data using the full precision provided by a digital measuring instrument.	12
		Apply standardized techniques for reading measurement tools to ensure accuracy when measuring the volume of a liquid.	13
		Calculate quantitative values by applying unit conversions and scale factors when using calibrated scientific instruments.	14
		Convert quantitative data between units within the same measurement system to express measurements in appropriate scales.	15
Communicating	involves using words, symbols, graphics, diagrams, graphs, tables, or oral representations to describe and exchange information about	Evaluate the effectiveness of different graphical representations for communicating trends and relationships in data over time.	16
		Select the most appropriate method of representation to effectively	17

	actions, objects, or events. This skill includes describing changes over time through writing or graphs (NARST, n.d.). This skill ensures effective dissemination of observational results, experimental findings, and conceptual interpretations to peers or broader audiences.	communicate changes in measurements over time.	
		Create detailed and accurately labeled diagrams to communicate structural information about scientific objects.	18
		Construct graphs with essential components such as axes labels, units, and titles to ensure clear and unambiguous communication of experimental data.	19
		Interpret graphical data to describe trends and relationships in written or oral form for disseminating findings.	20
Inferring	involves explaining observed phenomena by linking sensory data to prior knowledge or experiences (Kurniawati, 2021). It requires proposing reasoned explanations for events (e.g., hypothesizing why a chemical reaction occurs) rather than merely describing them. It identifies causes of observed events. It helps deduce why a specific incident occurred (Kurniawati, 2021). Inferring helps create an "educated guess" based on previously gathered data (NARST, n.d.).	Propose a causal explanation for an observed physical change by linking sensory data to prior knowledge of material properties.	21
		Infer that a chemical reaction is occurring by synthesizing multiple sensory observations (dissolving, gas production, temperature change).	22
		Identify a pattern or relationship from a structured data set to explain the effect of a manipulated variable.	23
		Distinguish an inference that explains a past event from a prediction about a future one within a statement that combines observation and reasoning.	24
		Deduce the most probable cause of a material's transformation by applying prior knowledge of common chemical processes to observed properties (e.g., color, texture change).	25
Predicting	involves projecting future events. Its bases are patterns or existing evidence. It could also involve making specific statements about possible outcomes (Kurniawati, 2021). Making effective prediction requires	Extrapolate a future data point by identifying and continuing a linear trend from a numerical data set.	26
		Forecast a future value by extending a quantitative trend from a graphical representation of data over time.	27
		Calculate a future outcome by applying a defined exponential pattern or rule to a current value.	28

	critical observations, precise measurements, and past experiences (Baxter & Kurtz, 2001). It requires stating event results grounded in evidence patterns. Examples include forecasting plant growth using historical data (NARST, n.d.).	Predict the outcome of a similar event by applying prior knowledge of patterns in the properties and behaviors of a group of elements.	29
		Project a specific outcome by applying a known pattern of response that includes a peak or optimum point.	30
Using Numbers	encompasses mathematical operations. It includes sorting, counting, adding, subtracting, multiplying, and dividing to quantify or analyze data (Kurniawati, 2021). This skill supports precise documentation and interpretation of measurements in scientific contexts.	Calculate the average (mean) from a series of quantitative counts to determine a central value.	31
		Extrapolate a future value in a sequence by identifying and continuing a consistent arithmetic pattern in measured data.	32
		Compute a new total by applying addition and subtraction operations to population data.	33
		Determine the total population by using division and multiplication to scale a sample count to 100%.	34
		Apply proportional reasoning to calculate the required quantities of components in a mixture based on a given ratio.	35
Using Space-Time	Relationships are recognized as a basic science process skill (Baharom et al., 2020; Irwanto, 2023; Kurniawati, 2021), though the provided literature does not furnish an explicit definition beyond its classification. It implies understanding spatial dimensions and temporal sequences in phenomena (e.g., tracking object motion over time) (Gizaw & Sota, 2023).	Interpret the slope of a distance-time graph to describe the motion of an object, such as constant speed.	36
		Select the appropriate velocity-time graph for an object moving under constant acceleration in one dimension, such as vertical motion.	37
		Calculate the future size of a population by applying exponential growth over multiple time intervals.	38
		Compute average speed by dividing distance by time and converting units as necessary.	39
		Apply the wave equation to calculate wave speed from given wavelength and frequency.	40

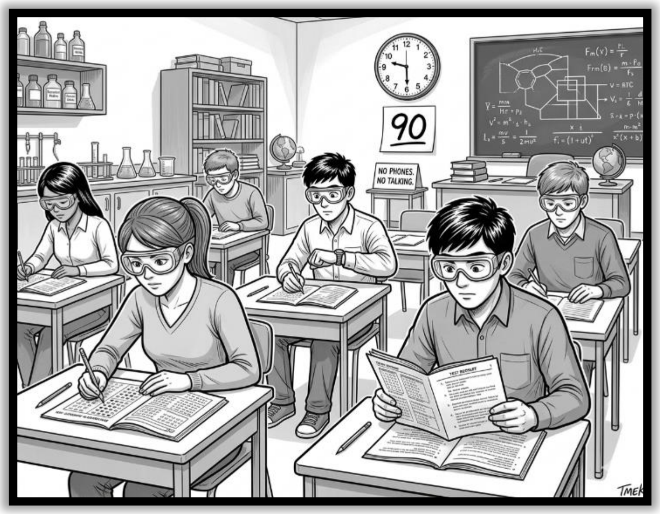
Identifying and Controlling Variables	involves identifying how different amounts or conditions shift during an experiment. This practice distinguishes independent variables, which the researcher manipulates; dependent variables, whose values adjust because of those changes; and controlled variables, which remain the same so the other effects can be seen clearly (Suman, 2017). Also, this skill requires determining which factors may influence experimental outcomes and systematically managing them (NARST, n.d.).	Identify the dependent variable in a described experimental setup that measures an outcome.	41
		Explain the purpose of controlling variables to isolate the effect of the independent variable on the dependent variable in an experiment	42
		Determine the independent variable in a described experimental setup where a condition is deliberately manipulated.	43
		Evaluate an experimental design to identify a key uncontrolled variable that could confound the results.	44
		Select a variable that must be controlled to ensure a fair test when comparing the effect of an independent variable.	45
Operationally Defining Variables	entails establishing clear, measurable parameters for variables within specific boundaries to simplify communication about phenomena under study. It differentiates definitions from related concepts using observable characteristics and expected operations (Kurniawati, 2021).	Formulate a clear and measurable parameter for an abstract concept to define a dependent variable in an experimental hypothesis.	46
		Evaluate the effectiveness of an operational definition based on its use of specific, observable, and measurable actions to quantify a complex behavior.	47
		Distinguish an operational definition from a conceptual one by identifying the definition that provides a specific, measurable procedure.	48
		Define a dependent variable operationally by specifying a precise, quantifiable metric for an abstract quality in a performance context.	49
		Compare operational definitions based on objectivity and consistency to determine which method provides a more reliable measurement of a property.	50
Formulating Hypotheses	is the process of making evidence-based	Formulate a testable if-then statement that predicts a specific,	51

	statements about potential relationships in the natural world. It involves suggesting explanations or solutions for observed problems. It is grounded in accurate observations or inferences (Baxter & Kurtz, 2001). Hypotheses state expected experimental outcomes (NARST, n.d.).	measurable outcome based on prior observations and research.	
		Propose a testable causal explanation for an observed phenomenon by linking separate observations into a reasoned inference.	52
		Derive a predictive hypothesis by identifying a correlational pattern in historical data and stating it as a testable relationship.	53
		Analyze a hypothesis to identify its strength as a statement that proposes a testable relationship between variables, regardless of the proposed mechanism.	54
		Distinguish the hypothesis (the testable claim) from the reasoning (the justification) within a statement that combines a prediction with its evidence-based rationale.	55
Interpreting Data	requires identifying patterns, relationships, and associations within collected information. This skill draws on prior experiences, observations, predictions, inferences, and hypotheses to analyze information systematically (Kurniawati, 2021). It involves organizing data to draw conclusions about variable interactions (NARST, n.d.).	Identify a direct relationship or trend by analyzing patterns in a structured data table.	56
		Analyze cyclical trends and patterns from a graphical representation of data over time to draw a conclusion about cause and effect.	57
		Draw a conclusion about variable interaction by comparing the outcomes of a controlled experiment to infer a causal relationship.	58
		Correlate the relationship between two variables by interpreting the trend shown in a scatter plot.	59
		Infer a probable cause for observed changes by comparing quantitative environmental data from different locations to identify significant disparities.	60
Experimenting (Testing Hypotheses Systematically)	constitutes a comprehensive process for evaluating hypotheses through structured investigations. It includes	Identify the independent variable within the design of a structured experiment set up to test a hypothesis.	61
		Control key environmental and material variables to ensure a fair test when	62

	asking questions, stating hypotheses, identifying/controlling variables, operationally defining variables, designing "fair" experiments, conducting tests and interpreting results to judge hypothesis validity (Baxter & Kurtz, 2001).	comparing the effect of an independent variable.	
		Draw a conclusion about the hypothesis by systematically comparing experimental results to determine if the data supports or refutes the initial prediction.	63
		Formulate a testable research question that guides the design of a structured experiment based on an initial observation.	64
		Construct a testable if-then hypothesis that predicts the specific effect of an independent variable on a dependent variable.	65
Formulating Models	involves creating mental, visual, or physical representations to explain ideas, objects, or events. It organizes experimental data symbolically to conceptualize processes, such as modeling evaporation-condensation dynamics in the water cycle (Ostlund, 1992; NARST, n.d.).	Utilize a physical, three-dimensional representation to manipulate and understand the spatial structure of complex molecules.	66
		Create a mental analogy to explain the function of a complex biological system by comparing it to a familiar mechanical system.	67
		Evaluate the limitations of a simplified visual model by identifying its inability to represent the full complexity of relationships in a system.	68
		Construct a visual diagram with symbolic representations to conceptualize and explain the stages of a cyclic natural process.	69
		Apply a computer simulation to project potential future outcomes and understand the behavior of a complex, large-scale system.	70

The Actual Test (Finally)

"56 questions. 90 minutes. No lab coat required. Just a pencil and a prayer."



GENERAL DIRECTIONS

Please read these instructions carefully before you begin.

Purpose of this Test:

This test is designed to assess your understanding and application of the skills scientists use to investigate and understand the natural world. These include making observations, designing experiments, analyzing data, and drawing conclusions.

Structure of the Test:

- The test is divided into two main parts: Basic Skills and Integrated Skills.
- It contains a total of 56 multiple-choice questions.
- Each question has four possible answers: A, B, C, and D.

Test-Taking Procedure:

- Read each question and all the answer choices thoroughly.
- Choose the BEST possible answer for each question.
- You are advised to answer every question. Your score will be based on the number of correct answers.
- You may use the blank spaces in this booklet for scratch work, but only answers on the answer sheet will be scored.

TIME ALLOTMENT:

You will have 90 MINUTES to complete this test. Manage your time wisely.

HONOR CODE:

This is an individual assessment. Do not communicate with other students or use unauthorized materials.

Select the correct answer.

1. *A class uses a light microscope to examine cells from a scraped onion skin stained with methylene blue. They see hundreds of rectangular units. Many of these units contain a small, dark, circular structure near the edge.*

   The small, dark, circular structure becomes visible primarily because of:
   A. the use of the microscope's stage clips to hold the slide steady.
   B. the use of the high-power objective lens, which changes the color of the cell.
   C. the adjustment of the mirror to maximize the light passing through the specimen.
   D. the staining process, which adds contrast to make specific structures absorb more light.

2. *Students are given two unlabeled powder samples, Sugar and Salt. They are instructed to observe them using multiple senses safely: sight, touch, and taste (by placing a tiny amount on a clean fingertip).*

   Which combination of observations provides the STRONGEST evidence for correct identification?
   A. *Color*: Both are white. *Taste*: One is sweet, one is salty.
   B. *Color*: Both are white. *Texture*: Both have fine, granular crystals.
   C. *Texture*: Both feel smooth. *Solubility*: Both dissolve completely in water.
   D. *Taste*: One is sweet, one is salty. *Crystal Shape*: One has cubic crystals, while the other has hexagonal or monoclinic crystals under magnification.

3. *To test the effect of fertilizer on plant growth, two groups of 10 identical seedlings are planted. Group A gets water only. Group B gets water with fertilizer. A student measures the height of all plants every Monday for four weeks using a ruler.*

   Why is measuring all the plants and repeating the measurement over time a stronger method than just measuring the largest plant in each group at the end?
   A. It allows the student to use a more precise instrument.
   B. It ensures the plants receive the same amount of sunlight.
   C. It makes the mathematical calculations for the average easier.
   D. It reduces the chance of bias and provides data on growth rate.

4. *A student is given images of six different insects and asked to sort them into two groups based on a single, observable physical characteristic.*

   Which of the following classification schemes uses a clear, observable characteristic to create two distinct groups?

	Group 1	*Group 2*
A.	Insects that are fast.	Insects that are slow.

B. Insects I have seen before.	Insects I have not seen before.
C. Insects with two pairs of wings.	Insects with one/no pair of wings.
D. Insects that are helpful to humans.	Insects that are harmful to humans.

5. *A geology student has four mineral samples (A, B, C, D) and wants to order them from softest to hardest. They perform a scratch test, where a mineral can scratch any mineral softer than itself. The results are:*

   Sample A scratches B and C.
   Sample B is scratched by D but not by C.
   Sample C is scratched by A and D.
   Sample D scratches A, B, and C.

   Based on the scratch test results, what is the correct order from softest (1) to hardest (5)?

   A. B, C, D, A
   B. D, C, B, A
   C. C, B, D, A
   D. C, B, A, D

6. *A dichotomous key for leaves:*

Category	*Indicator*
1. Leaf Edge	*1a. smooth............... Go to 2* *1b. serrated (toothed).......Go to 3*
2. Leaf Vein Pattern	*2a. parallel...........Group X* *2b. palmate (spread from a central point).........Group Y*
3. Leaf type	*3a. compound (multiple leaflets).........Group Z* *3b. simple.......................Group W*

   A student has a leaf with a smooth edge and veins spreading from a central point. According to the key, how should this leaf be classified?

   A. Group W
   B. Group X
   C. Group Y
   D. Group Z

7. *A scientist classifies animals as follows:*

   Group 1: Dolphin, Bat, Kangaroo, Human
   Group 2: Penguin, Turtle, Snake, Crocodile

   The most likely basis for this classification is:

	Category	Group 1	Group 2
A.	*Locomotion*	can walk	can swim
B.	*Diet*	are herbivores	are carnivores

C. *Habitat*	lives on land	lives in water
D. *Reproductive strategy*	are mammals	are reptiles

8. *Two students are classifying the same set of metals.*
Student 1 groups them as: Shiny vs. Dull.
Student 2 groups them as: Conducts heat and electricity vs. Does not conduct heat and electricity.

Which statement BEST evaluates the two classification systems?

A. Both systems are invalid because they do not consider the metals' densities.
B. Both systems are equally valid because each uses a consistent a single characteristic.
C. Student 1's system is better because shininess is a property that can be determined without special equipment.
D. Student 2's system is better because conductivity is a property more closely related to the metals' atomic structure and behavior.

9. *A student wants to measure the mass of a seed. The seed is about the weight of a grain of rice.*

Which tool and unit would be most appropriate for this measurement?

A. A ruler measuring in centimeters.
B. A bathroom scale measuring in kilograms.
C. A kitchen digital scale measuring in grams.
D. A graduated cylinder measuring in milliliters.

10. *A student is using a digital balance to measure the mass of a chemical. The balance reads 2.345 grams.*

How should the student record this measurement?

A. 2.3 grams (rounding to two significant figures)
B. 2.34 grams (rounding to three significant figures)
C. 2.345 grams (recording all four significant figures)
D. 2.35 grams (rounding to the nearest hundredth)

11. *A student needs to measure exactly 25.0 mL of water using a 50 mL graduated cylinder with 0.5 mL markings. What is the correct technique to ensure an accurate reading?*

What is the correct way to read the volume?

A. Read the volume from the top of the meniscus while the cylinder is on the table.
B. Read the volume from the bottom of the meniscus while holding the cylinder.

C. Read the volume from the top of the meniscus while holding the cylinder at eye level.
D. Read the volume from the bottom of the meniscus at eye level with the cylinder at a level surface.

12. *A student calibrates an ocular micrometer with a stage micrometer. They find that 8 ocular divisions correspond to 0.08 mm on the stage micrometer. If a cell spans 5 ocular divisions, what is the length of the cell?*

What is the length of the cell?
A. 0.005 mm
B. 0.01 mm
C. 0.05 mm
D. 0.5 mm

13. *A student has a liquid with a density of 1200 g/L.*

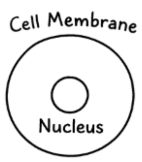
If they measure 1500 milliliters of this liquid, what is its mass in kilograms? (Recall: 1 L = 1000 mL)
A. 0.18 kg
B. 1.8 kg
C. 18 kg
D. 180 kg

14. *A student records the temperature of a pond at the same time and location every day for one month. They want to present their findings to the class.*

Which method would be MOST effective for communicating how the temperature changed throughout the month?
A. Data recording of thirty individual temperature values in order.
B. Calculating and stating only the average temperature for the month.
C. Creating a data table with two columns: "Date" and "Temperature (°C)".
D. Plotting the data on a line graph with "Date" on the x-axis and "Temperature" on the y-axis.

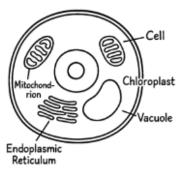
15.

Student A



Student A draws a circle, writes "Nucleus," and draws a larger circle around it labeled "Cell Membrane."

Student B



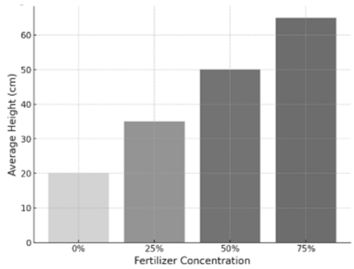
Student B draws a detailed diagram showing the nucleus, cell membrane, mitochondria, chloroplasts, vacuole, and endoplasmic reticulum, with each part clearly labeled.

Which statement BEST evaluates the communication of these diagrams?

A. Student A's diagram is more effective for a beginner audience because it focuses only on the essential features.
B. Student B's diagram is more effective because the labels and details help communicate the cell's complexity and functions.
C. Both diagrams are ineffective for scientific communication because they are hand-drawn and lack photographic precision.
D. The effectiveness depends on the presentation topic; Student A's diagram is better for basic concepts, while Student B's is better for advanced topics.

16.

Average Height of the Sunflower Plants at Different Fertilizer Concentrations

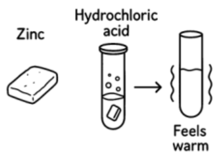


A bar graph shows the average height of sunflower plants grown in four different concentrations of fertilizer.

Which written statement BEST communicates the overall trend shown in the graph?

A. Applying fertilizer leads to improved growth and overall health outcomes.
B. The sunflower plants in the experiment were tall across the different treatment groups.
C. The graph shows four bars with distinct heights representing a specific percentage of fertilizer.
D. As the concentration of fertilizer increased, the average height of the sunflowers also increased.

17.



A student adds a piece of zinc to a solution of hydrochloric acid. They observe that zinc dissolves and bubbles of gas form. The test tube feels warm.

Which statement BEST explains these observations?

A. The zinc is condensing out of the solution.
B. The acid is evaporating, creating gas bubbles.

C. The zinc is melting due to the warmth of the acid.
D. The substances react, producing a gas and releasing heat.

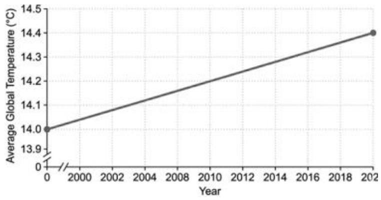
18. *A student rolls a ball down ramps of different slopes. They measure the distance the ball travels on the floor after leaving each ramp.*

Ramp Slope (degrees)	***Distance Traveled (cm)***
10	15
20	30
30	45
40	60

Based on the data pattern, which statement best describes the relationship between ramp slope and distance?

A. The distance traveled is unaffected by the slope angle.
B. The distance traveled decreases as the slope angle increases.
C. The distance traveled is directly proportional to the slope angle.
D. The distance traveled increases with the slope angle, but the rate of increase may not be constant.

19. **Average Global Temperature (2000-2020)**



Line graph shows the average global temperature from 2000 to 2020. The trend shows a steady increase of 0.2°C per decade.

If the trend continues, what is the predicted temperature change from 2020 to 2030?

A. Increase by 0.2°C
B. Increase by 0.4°C
C. Decrease by 0.2°C
D. Remain the same

20. *Magnesium and calcium are both in Group 2 of the periodic table. When magnesium ribbon is burned in air, it produces a bright white light and a white powder.*

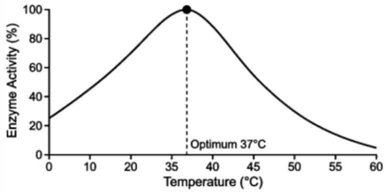
Based on this, what would happen if calcium is burned in air?

A. It would react slowly with a red glow and produce a yellow powder.
B. It would not react because calcium is less reactive than magnesium.
C. It would produce a white powder but no light due to its higher density.

D. It would react vigorously with a bright white light and produce a white powder.

21.

Effect of Temperature on Enzyme Activity



The experiment shows that enzyme activity increases with temperature up to 37°C, but above 37°C, activity decreases.

If the temperature is raised to 40°C, what would likely happen to the enzyme activity?

A. It will increase rapidly as kinetic energy continues to rise.
B. It will stop completely as the enzyme instantly denatures.
C. It will decrease because the enzyme structure becomes distorted.
D. It will remain unchanged since the enzyme is already at peak efficiency.

22.

A biologist counts the number of birds in a forest over three days:

Day	***No. of Birds***
1	*120*
2	*135*
3	*150*

What is the average number of birds counted per day?

A. 120
B. 135
C. 150
D. 405

23.

A student measures the growth of a plant in centimeters each week: Week 1: 5 cm, Week 2: 7 cm, Week 3: 9 cm, Week 4: 11 cm.

If the pattern continues, how tall will the plant be in Week 5?

A. 12 cm
B. 13 cm
C. 14 cm
D. 15 cm

24. A scientist counts 40 cells in a microscope view. The view represents 1% of the total sample. How many cells are in the total sample?

A. 40
B. 400
C. 4000
D. 40,000

25. A recipe for a chemical solution requires 3 parts chemical A and 5 parts chemical B. If you use 15 mL of chemical A, how much chemical B is needed?

A. 9 mL
B. 15 mL
C. 25 mL
D. 30 mL

26. **Distance-Time Graph of a Car Travelling on a Straight Road**

A car travels along a straight road. The distance-time graph shows a straight line sloping upwards.

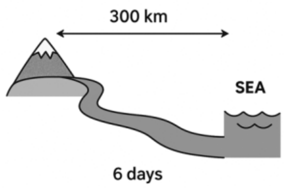
What does this graph indicate about the car's motion?

A. The car is at rest.
B. The car is accelerating.
C. The car is decelerating.
D. The car is moving at a constant speed.

27. A bacterial colony doubles in size every hour. If it starts with 100 bacteria, how many will there be after 3 hours?

A. 200
B. 400
C. 600
D. 800

28.

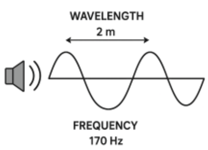


A river flows from a mountain to the sea. The distance is 300 km, and the water takes 6 days to travel this distance.

What is the average speed of the river flow?

A. 50 km/day
B. 18 km/day
C. 2.08 km/h
D. Both A and C

29.



A sound wave travels through air. The wavelength is 2 meters, and the frequency is 170 Hz.

What is the speed of the sound wave?

A. 85 m/s
B. 172 m/s
C. 200 m/s
D. 340 m/s

30. A student wants to test if the amount of fertilizer affects the growth rate of tomato plants. They use different amounts of fertilizer on different plants but keep the type of soil, amount of water, and sunlight the same for all plants. They measure the height of each plant every week.

What is the dependent variable in this experiment?

A. The type of tomato plant used.
B. The number of weeks the plants are grown.
C. The amount of fertilizer applied to each plant.
D. The change in plant height as a measure of growth.

31. In the same fertilizer experiment, the student keeps the type of soil, amount of water, and sunlight the same for all plants.

Why is it important to keep the amount of water the same for all plants?

A. To avoid the need for frequent watering of plants.
B. To make certain that all plants remain equally healthy.
C. To save time and effort during the conduct of experiments.
D. To ensure that fertilizer is the only variable affecting plant growth.

32. A scientist hypothesizes that the temperature of water affects how quickly sugar dissolves. They design an experiment where they stir sugar into beakers of water at 20°C, 40°C, and 60°C. They measure the time it takes for the sugar to dissolve in each beaker.

What is the independent variable?

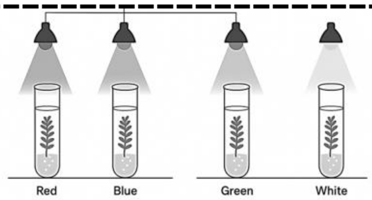
A. The volume of water used.
B. The amount of sugar used.
C. The temperature of the water.
D. The time it takes for the sugar to dissolve.

33. Two students test which paper airplane design flies the farthest. Student 1 throws Design A and Student 2 throws Design B. They each throw their plane once and measure the distance.

What is the major flaw in their experimental design regarding variables?

A. They did not test a sufficient number of paper airplane designs.
B. The person throwing the plane is a variable that is not controlled.
C. They should have used a more durable type of paper for the planes.
D. They did not use proper techniques to measure the flight distance correctly.

34.



An experiment is designed to test if the color of light affects the rate of photosynthesis in water lily. The independent variable is the color of light, and the dependent variable is the rate of photosynthesis (measured by oxygen bubbles produced).

Which of the following should be controlled to ensure a fair test?
A. The color of light applied.
B. The intensity of the light source.
C. The amount of oxygen produced.
D. The conclusion drawn from the data.

35 A student is designing an experiment to test the hypothesis: "Stress affects plant health."

Which of the following is the BEST operational definition for the dependent variable "plant health"?
A. The number of new leaves produced over two weeks.
B. The plant's health scored on a subjective rating scale.
C. The plant's disease resistance measured by infection tests.
D. The leaf color measured using a comprehensive color chart.

36. A team is studying "aggression" in mice. They propose the following operational definition: "Aggression will be measured by counting the number of times one mouse charges at another mouse within a 10-minute observation period."

Why is this an effective operational definition?
A. It identifies the internal emotional state of the mouse.
B. It turns an abstract concept into something measurable.
C. It explains the biological reasons for aggressive behavior.
D. It guarantees complete recording of all aggressive behaviors.

37. A coach wants to test if a new training regimen improves "athletic performance." Which of the following operational definitions sets a clear, measurable parameter for the dependent variable?
A. The athlete's level of exhaustion after training.

B. The athlete's personal feeling of improvement.
C. The time in seconds it takes to run 100 meters.
D. The coach's rating of the athlete's effort on a scale of 1 to 10.

38. In a taste-test experiment, one group defines "sweetness" as "the taster's score on a sweetness scale from 1 to 5." Another group defines it as "the concentration of sugar in grams per liter measured with a refractometer."

What is a key advantage of defining sweetness based on sugar concentration measured with a refractometer?

A. This method is cheaper and straightforward to use.
B. It is more subjective and captures human perception.
C. It yields objective and consistent data without human bias.
D. It produces results that are less accurate than subjective scores.

39. *A student observes that tomato plants grown in compost seem larger than those grown in regular soil. After researching, they learn compost is rich in nutrients.*

Which statement is the BEST evidence-based hypothesis the student could test?

A. Tomato plants are the best plants to grow in a compost soil than in a regular soil.
B. Compost is dark brown and smells earthy which affects the growth of the tomato.
C. If tomato plants are grown in compost, then they will produce more fruit than plants grown in regular soil.
D. The weather affected the nutrient absorption of plants which are grown in both compost and regular soil.

40. *A student notes, "The pond water is cloudy and green. There are many frogs around the pond."*

Which follow-up statement is a testable hypothesis based on these observations?

A. The pond was created artificially for landscaping.
B. The cloudy water is making it harder for frogs to see prey.
C. The green color is due to algae growth stimulated by sunlight.
D. The frogs are causing the water to turn green by releasing chemicals.

41. *A farmer's data log shows that her squash crop yield decreases in years when the summer is unusually rainy.*

Based on this pattern, what is a reasonable hypothesis for the farmer to test next year?

A. Squash grows best during the dry season.
B. If summer rainfall is high, then squash yield will be lower.
C. Heavy rain makes squash dirty and causes fungal growth.
D. I should grow watermelons instead when summer rainfall is high.

42. *A student proposes the following hypothesis: "If a plant is talked to every day, then it will grow taller because sound vibrations cause plant cells to divide faster."*

What is the main strength of this hypothesis?

A. It is guaranteed to be true.
B. It will be very easy to prove.
C. It states a testable relationship.
D. It is based on evidence, not a popular myth.

43. *A student says, "I think the fish in Tank A will be more active than the fish in Tank B. I think this because Tank A has a higher oxygen level, and oxygen is needed for energy."*

Which part of this statement is the hypothesis?

A. Oxygen is needed for energy.
B. Tank A has a higher oxygen level.
C. The fish in Tank A will be more active.
D. The reason for connecting higher oxygen to more activity.

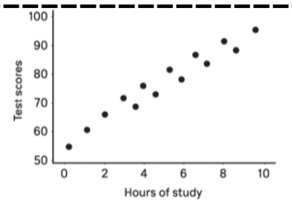
44. *A table shows the average height of sunflowers grown with different amounts of fertilizer:*

Fertilizer (g/week)	***Average Height (cm)***
0	50
5	65
10	80
15	95

Based on the data, which statement best describes the relationship between fertilizer amount and plant height?

A. Fertilizer amount has no effect on plant height.
B. Higher fertilizer amounts cause plant height to decrease.
C. Plant height increases at a constant rate with fertilizer amount.
D. Plant height increases, but the rate of increase may change with more fertilizer.

45.



The Effect of Study Hours on Test Scores

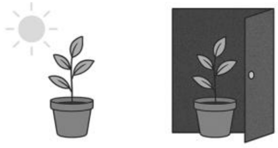
What does this trend indicate?

A. The data lacks any consistent pattern.
B. Less studying is linked to better scores.
C. More studying is associated with higher test scores.
D. There is no relationship between studying and scores.

46. A data table shows water quality measurements upstream and downstream from a factory:

Location	*Dissolved Oxygen (mg/L)*	*Turbidity (NTU)*
Upstream	*8.5*	*10*
Downstream	*4.2*	*45*

What can be inferred about the factory's impact?
A. The factory improves water quality.
B. The factory has no effect on the water.
C. The factory may be polluting the water.
D. The data is insufficient to draw a conclusion.

47. 

The student designs an experiment to test the hypothesis by placing one plant in direct sunlight and another in a dark closet.

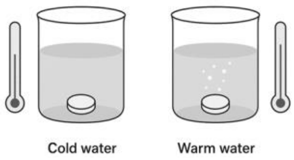
What is the independent variable in this experiment?
A. The type of plant
B. The height of the plant
C. The amount of sunlight
D. The amount of water given

48. In the same experimental setup, when testing the effect of fertilizer on plant growth, which factor is most important to control to ensure a fair test?
A. The color of the pots
B. The amount of fertilizer used
C. The type of soil and the amount of water
D. The time of day the plants are measured

49. Refer to this null hypothesis

H_o: Sunlight has no effect on the growth of the plants.

After two weeks, the plant in sunlight is 20 cm tall, and the plant in the closet is 10 cm tall. What conclusion can be drawn from these results?
A. The null hypothesis is accepted because both plants grew.
B. The null hypothesis is rejected because the experiment was invalid.
C. The null hypothesis is accepted because the height difference is small.
D. The null hypothesis is rejected because the plant in sunlight grew taller.

50. 

A student observes that an effervescent tablet dissolves faster in warm water than in cold water.

Which question would lead to a testable experiment?

A. How much does effervescent tablet cost?
B. What is the chemical composition of effervescent tablet?
C. Why does effervescent tablet dissolves faster in warm water?
D. Does temperature affect the dissolution rate of effervescent tablet?

51. The student decides to test the effect of surface area on dissolution rate. Which hypothesis is CORRECTLY formulated?

A. Smaller pieces are better for dissolution, especially for tablets.
B. Dissolution rate is always affected by changes in surface area.
C. If the surface area of a tablet is increased, then it will dissolve faster.
D. An effervescent tablet dissolves in water regardless of its surface area.

52. *A biology teacher provides students with a large, three-dimensional plastic model of a DNA molecule that can be taken apart and reassembled.*

What is the main advantage of using this physical model instead of just a textbook diagram?

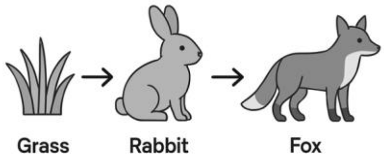
A. It reduces long-term costs since it can be reused annually without replacement.
B. It is more environmentally sustainable than paper diagrams as it generates less waste.
C. It allows students to learn the structure without needing to understand the chemical components.
D. It helps students visualize the hydrogen bonding between nucleotides through hands-on manipulation.

53. *A student is trying to understand how the heart functions as a pump. They think of it like a mechanical water pump that squeezes to push fluid through pipes.*

What has the student created to help their understanding?

A. A hypothesis
B. A scientific law
C. A mental model
D. A research paper

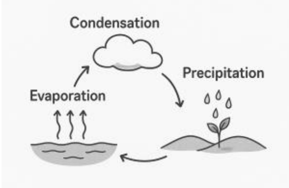
54.



What is a key scientific limitation of this simple model?

A. It is drawn in two dimensions instead of three.
B. It fails to show the initial energy source from the sun.
C. It does not account for multiple predators or prey in a complex food web.
D. It implies that population sizes can be exactly determined from the diagram.

55.



To explain the water cycle, a student draws a diagram with arrows showing water moving from a lake to the sky (evaporation), forming clouds (condensation), and falling back to the ground as rain (precipitation).

What has the student created?

A. A list of important facts and processes about water.
B. A model to conceptualize a complex natural process
C. A hypothesis to be tested during inquiry-based lessons.
D. A contextualized example of a possible investigation on phase change.

56. *A scientist uses a computer model of global atmospheric circulation to simulate what might happen to global rainfall patterns if average temperatures continue to rise.*

What is the primary function of the model in this case?

A. To compile and maintain a detailed record of past weather events for historical analysis.
B. To serve as a visual tool that enhances understanding and engagement during a presentation.
C. To represent the climate system and project potential future outcomes based on current data.
D. To perform real-world experimental tests on the atmosphere using practical methods and measurements.

GLOSSARY

Basic science process skills – Foundational skills including observing, classifying, measuring, communicating, inferring, predicting, using numbers, and using space-time relationships.

Classifying – Grouping objects or events based on similarities, differences, or defined criteria.

Communicating – Using words, symbols, graphs, or diagrams to exchange scientific information.

Content Validity Index (CVI) – A statistical measure of expert agreement that test items are relevant and appropriate for the target population.

Controlled variable – A factor kept constant across all experimental conditions to ensure a fair test.

Dependent variable – The measured outcome that may change in response to manipulation of the independent variable.

Dichotomous key – A tool that uses paired observable characteristics to identify organisms or objects.

Experimenting – Testing hypotheses through structured investigations including variable control, trials, and data interpretation.

Formulating hypotheses – Creating testable statements predicting relationships between variables, often in "if-then" format.

Formulating models – Creating physical, visual, mathematical, or analogical representations to explain scientific ideas or processes.

Hypothesis – A testable prediction about the relationship between variables.

Identifying and controlling variables – Recognizing which factors change (independent), which are measured (dependent), and which must stay constant (controlled).

Independent variable – The factor deliberately manipulated by the researcher.

Inferring – Explaining observed phenomena by linking sensory data to prior knowledge.

Integrated science process skills – Advanced skills combining multiple basic skills: identifying/controlling variables, operational definition, formulating hypotheses, interpreting data, experimenting, and formulating models.

Interpreting data – Analyzing collected information (tables, graphs) to identify patterns, relationships, or trends.

Kuder-Richardson Formula 20 (KR-20) – A reliability coefficient for tests with dichotomous items (correct/incorrect).

Measuring – Comparing physical properties (length, mass, volume, temperature) to standardized units using appropriate tools.

Meniscus – The curved surface of a liquid in a container; read at the bottom for accurate volume measurement.
Null hypothesis – A statement that no relationship or effect exists between variables.
Observing – Gathering information about objects or events using the senses or instruments that aid the senses.
Operational definition – A clear, measurable specification of how an abstract variable will be quantified in a study.
Predicting – Projecting future events or outcomes based on patterns or existing evidence.
Pre-service teacher – A student enrolled in a teacher education program training to become a teacher.
Science process skills (SPS) – The abilities scientists use to investigate the natural world.
Table of Specifications (TOS) – A blueprint showing which skills each test question assesses and their distribution.
Using numbers – Performing mathematical operations (counting, adding, subtracting, multiplying, dividing) to quantify or analyze data.
Using space-time relationships – Understanding how objects move or change over time and space; interpreting motion graphs.
Variable – Any factor that can change or be changed in an experiment.

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APPENDIX A
SAMPLE ANSWER SHEET
Science Process Skills Test (SPST)

Student Information (Please print clearly)

Field	Response
Full Name (Last, First, Middle Initial)	________________________________
Student ID Number	________________________________
Year Level	☐ 1st Year ☐ 2nd Year ☐ 3rd Year ☐ 4th Year
Gender	☐ Male ☐ Female ☐ Non-binary/Third Gender ☐ Prefer to self-describe: _______ ☐ Prefer not to say
Age	_______
Date of Test	________________________________
Test Administrator	________________________________

Instructions to the Student:

- Use a **pencil** to shade the circle completely.
- Make sure your marks are dark and clean.
- Erase completely if you change an answer.
- Do not make any stray marks on this answer sheet.
- Each question has **only one** correct answer.

A. Basic Science Process Skills **Basic SPS Score:**______/29

1.	ⓐ ⓑ ⓒ ⓓ	11.	ⓐ ⓑ ⓒ ⓓ	21.	ⓐ ⓑ ⓒ ⓓ
2.	ⓐ ⓑ ⓒ ⓓ	12.	ⓐ ⓑ ⓒ ⓓ	22.	ⓐ ⓑ ⓒ ⓓ
3.	ⓐ ⓑ ⓒ ⓓ	13.	ⓐ ⓑ ⓒ ⓓ	23.	ⓐ ⓑ ⓒ ⓓ
4.	ⓐ ⓑ ⓒ ⓓ	14.	ⓐ ⓑ ⓒ ⓓ	24.	ⓐ ⓑ ⓒ ⓓ
5.	ⓐ ⓑ ⓒ ⓓ	15.	ⓐ ⓑ ⓒ ⓓ	25.	ⓐ ⓑ ⓒ ⓓ
6.	ⓐ ⓑ ⓒ ⓓ	16.	ⓐ ⓑ ⓒ ⓓ	26.	ⓐ ⓑ ⓒ ⓓ
7.	ⓐ ⓑ ⓒ ⓓ	17.	ⓐ ⓑ ⓒ ⓓ	27.	ⓐ ⓑ ⓒ ⓓ
8.	ⓐ ⓑ ⓒ ⓓ	18.	ⓐ ⓑ ⓒ ⓓ	28.	ⓐ ⓑ ⓒ ⓓ
9.	ⓐ ⓑ ⓒ ⓓ	19.	ⓐ ⓑ ⓒ ⓓ	29.	ⓐ ⓑ ⓒ ⓓ
10.	ⓐ ⓑ ⓒ ⓓ	20.	ⓐ ⓑ ⓒ ⓓ		

B. **Integrated Science Process Skills** **Integrated SPS Score:**_______/27

1.	ⓐ ⓑ ⓒ ⓓ	11.	ⓐ ⓑ ⓒ ⓓ	21.	ⓐ ⓑ ⓒ ⓓ
2.	ⓐ ⓑ ⓒ ⓓ	12.	ⓐ ⓑ ⓒ ⓓ	22.	ⓐ ⓑ ⓒ ⓓ
3.	ⓐ ⓑ ⓒ ⓓ	13.	ⓐ ⓑ ⓒ ⓓ	23.	ⓐ ⓑ ⓒ ⓓ
4.	ⓐ ⓑ ⓒ ⓓ	14.	ⓐ ⓑ ⓒ ⓓ	24.	ⓐ ⓑ ⓒ ⓓ
5.	ⓐ ⓑ ⓒ ⓓ	15.	ⓐ ⓑ ⓒ ⓓ	25.	ⓐ ⓑ ⓒ ⓓ
6.	ⓐ ⓑ ⓒ ⓓ	16.	ⓐ ⓑ ⓒ ⓓ	26.	ⓐ ⓑ ⓒ ⓓ
7.	ⓐ ⓑ ⓒ ⓓ	17.	ⓐ ⓑ ⓒ ⓓ	27.	ⓐ ⓑ ⓒ ⓓ
8.	ⓐ ⓑ ⓒ ⓓ	18.	ⓐ ⓑ ⓒ ⓓ		
9.	ⓐ ⓑ ⓒ ⓓ	19.	ⓐ ⓑ ⓒ ⓓ		
10.	ⓐ ⓑ ⓒ ⓓ	20.	ⓐ ⓑ ⓒ ⓓ		

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His research interests include science process skills, learning agency, and teacher education.

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