Course: Teaching Strategies in Science Education (696)
Semester: Spring, 2022

ASSIGNMENT No. 2

Q.1 How enquiry helps learners to understand concepts of science? Provide examples for the content of any of your choice.

Inquiry-based science education (IBSE) has been proposed as a framework for conceptualizing the priorities and values of authentic science teaching and learning. The main features of this framework include active pupil engagement in the learning process with emphasis on supporting knowledge claims with observations, experiences or complementary sources of credible evidence; tackling of authentic and problem-based learning activities; consistent practice and development of the skills of systematic observation, questioning, planning and recording with a purpose to obtain credible evidence; committed participation in collaborative group work, peer interaction, construction of discursive argumentation and communication with others as the main process of learning; and the development of autonomy and self-regulation through experience as important goals of learning. IBSE has also been misconstrued as a teaching method for better engaging students or as scaffolding structure for designing learning environments. In this chapter, we will first elaborate on these distinctions and will discuss the implications for science education reform. We will present an overview of the educational policy priorities that have been formulated at European level for IBST/L, and we will discuss the opportunities and constraints that these efforts have generated for science education and science teacher professional development across European contexts. The chapter provides a framing text for the case studies in the remainder of the book. As such, it identifies issues and sets the tone for what follows, alerting the reader to both the problematics and the unavoidable complexity that emerge from efforts to highlight broad educational objectives at a level that is far removed from student and teacher experience as well as local societal priorities. Inquiry-based science adopts an investigative approach to teaching and learning where students are provided with opportunities to investigate a problem, search for possible solutions, make observations, ask questions, test out ideas, and think creatively and use their intuition. In this sense, inquiry-based science involves students doing science where they have opportunities to explore possible solutions, develop explanations for the phenomena under investigation, elaborate on concepts and processes, and evaluate or assess their understandings in the light of available evidence. This approach to teaching relies on teachers recognizing the importance of presenting problems to students that will challenge their current conceptual understandings so they are forced to reconcile anomalous thinking and construct new understandings. Inquiry-based science challenges students' thinking by engaging them in investigating scientifically orientated questions where they learn to give priority to evidence, evaluate explanations in the light of alternative explanations and learn to communicate and justify their decisions. These are dispositions needed to promote and justify their decisions. In short, "Scientific inquiry requires the use of evidence, logic, and imagination in developing explanations about the natural world" Teachers can gauge the success of their teaching through students' level of engagement with the topic and each other, the scientific language they use to communicate their ideas, and the quality of the work they produce. Subtle comments such as "Are we doing science today? I really liked the way we did...." Are

typical of the types of comments students will make when they have enjoyed participating in science investigations.

1. Inquiry increases rigor and cognitive load

Inquiry-based learning pushes students beyond simply learning to memorize or remember, and toward applying knowledge in new domains, drawing connections among ideas, evaluating or challenging ideas, and additionally creating something completely new.

2. Inquiry increases engagement and interest

Inquiry-based learning connects a new concept or area of study with students own interests and lived experience. Therefore, this methodology awakens their natural **curiosity**. This Increasing engagement in learning experiences, hence are more relevant to students' lives .

3. Inquiry increases intellectual risk-taking

Inquiry-based learning experiences push students out of their comfort zone. Because it focuses more on exploring environments of varying levels of ambiguity, it lowers the perceived need to "get it right" that would otherwise make students wary of intellectual risk-taking.

Yet we've found that students are often enjoying themselves so much they don't even notice they're out of their comfort zone, happily exploring uncharted intellectual territory!

4. Inquiry develops key soft skills

Inquiry-based learning also effectively develops important soft skills that are key for student success in the 21st Century, such as creative problem solving, critical thinking, logical thinking, teamwork, and even written and oral communication.

5. Inquiry is a natural differentiator

With **Inquiry-based learning**, because they have a degree of autonomy to select how they want to approach a task, students have leeway to select a learning pathway that appeals to their preferred learning style. Students then have the space to learn in a way that makes sense to them.

There are also many possibilities for purposeful differentiation—since **inquiry-based learning** activities are naturally student-driven and semi-autonomous, teachers are free to circulate and give individualized instruction, small-group support, and extension activities to students who need it most.

6. Inquiry transforms a classroom of students into a classroom of teachers

Inquiry-based teaching can easily be combined with **collaborative** groupings. Because that allow students to work and learn as teams.

With clearly set expectations and carefully defined roles, students explore, discuss, and come up with creative ways to approach a complex task, **learning more as a team** than they would individually.

Often, peer learning is just as effective as teacher-led learning. Indeed, the most meaningful **"aha!" moments** often come in authentic interactions with peers. Then suddenly, your class is transformed into space **where EVERYONE is a teacher**!

7. Inquiry creates lifelong learners

Inquiry-based learning helps students become **lifelong learners**.

Life is about learning to navigate unfamiliar situations, and coming up with creative solutions in environments of uncertainty will help students find success not only in their current academic careers but will also help them adapt to a workforce and world that will continue to evolve in unexpected ways.

8. Inquiry triggers new approaches to solve a new type of problem

The global issues that our world is facing today are known as "**wicked**". Problems for they're more complex than any problem our society has ever faced before.

There is no longer any good or bad solution able to solve a wicked problem such as climate change, nor there is any definite set of solutions to end world hunger, or any limit to scientific discoveries and innovations responding to the endless list of challenges humanity is facing.

Therefore, we need to enable the next generation today to face the world of tomorrow with a more dynamic and innovative way of thinking about problems.

And this is what **inquiry-based learning teaches them** to do by triggering their **critical thinking capacities** and pushing them to take action instead of learning passively.

9. Inquiry as a source of self-confidence

Inquiry-based learning allows students to embrace and feel comfortable with still with the possibility of making errors. Making it rather an opportunity for improvement.

Q.2 Compare course and lesson planning for science teaching. Identify the components that are compulsory for classroom teaching.

Whether you teach several subjects or teach in a specific content area, lesson plans matter. The quality of your lesson plans will in great part determine how efficiently class time is used and how much content your students learn each period.

Lesson plans don't have to be lengthy. The main thing is to make sure they contain the main elements of the lesson. They're meant to guide your instruction so you can maximize classroom time.

- Necessary Materials
- Clear Objectives
- Background Knowledge
- Direct Instruction
- Student Practice
- Closure
- Demonstration of Learning (Quick Assessment)

1. Gather Your Materials

What will you need to teach this lesson? This includes student supplies as well as your own. Don't forget about technology such as your document camera and laptop.

Make sure you have everything situated so you're ready to roll when your students arrive. You don't want to be scrambling around in the middle of a lesson trying to locate the protractors which you thought were in that bottom cabinet, only to realize at the last minute they're not there.

Having your resources lined up ahead of time saves valuable class time and gives you great peace of mind. When your materials are in place, you can devote all your energy to teaching the lesson.

Your materials list may look something like this:

Materials

- lined paper
- pencils
- rulers
- Kagan chips
- document camera
- laptops

Remember

Begin planning your lesson with the end in mind. Plan backwards by knowing in advance exactly what you want your students to grasp by the end of the lesson.

2. Know Your Class Objectives

What exactly do you want your students to be able to do by the end of the lesson? This should be clearly communicated to your students verbally at the very beginning of the lesson and posted in a highly visible location in your classroom.

It's helpful to have a specific place in your room where you regularly post your objectives, and to have a set routine in terms of how you introduce the objectives, such as asking your students to read them aloud with you at the beginning of class each day.

Communicating the learning objectives to your students, both verbally and in writing, serves to motivate them to work with a clear purpose in mind, and it makes it easier for you and your students to stay on target throughout the lesson.

The objectives should be the ongoing focus of your lesson. Maximize your effort to create successful learning outcomes with SMART objectives. SMART stands for specific, measurable, attainable, relevant, and time-bound.

3. Activate Background Knowledge

Set the stage by tapping into your students' background knowledge—previous life experiences, prior learning, or both—to prepare them for the new concept you're about to introduce.

The point is to make connections between what your students already know and what you're going to teach them. For example, if you're about to present a lesson on using metaphors and similes in writing, start out by discussing what makes a story engrossing to a reader.

Involve your students in the discussion by asking them to share their thoughts based on gripping stories they've read. Some responses you may get are: "interesting characters," "interesting plot," "suspense," and "ability to relate to the characters or plot."

Perhaps you have taught other forms of figurative language such as hyperboles and personification, earlier in the school year. Review these briefly. These discussions will lead right into your lesson of using metaphors and similes as additional ways to make a story captivating to readers!

Be sure to model plenty of examples as part of your direct instruction.

4. Direct Instruction

This is the "meat" of your lesson plan. It's where you present the new concept that is included in the lesson objectives.

Prepare your students for success by pre-teaching key vocabulary words that are essential to understanding the concept or text you will introduce to them. When students know these key words in advance, they can focus more of their energy on learning the concept or understanding the text.

Speak clearly and concisely. Less is more as long as you stay on topic. Use the board or a document camera as you model what you're teaching. If the lesson involves a process, then show the process. Speak aloud as you model through it, explaining each step as you go along.

Be sure to take your time. Modeling is a critical part of direct instruction. When students watch and listen to you apply the concept, they are much better able to understand what you're trying to teach them. It is important to model multiple examples of the concept you're introducing!

When you teach, the key is to gradually release your students from watching you model the correct application of the concept to allowing them to apply the concept independently.

5. Student Practice

Student practice consists of three steps: guided practice, collaborative practice, and independent practice.

This three-step process allows you to gradually release your students from watching you model the correct application of the concept to allowing them to apply the concept independently.

1. Guided Practice

After you've presented the new concept and modeled a few examples on your own, involve your students in a few additional examples using the board or document camera. They will gain confidence as they go through the process with you!

Converse with them through the process, questioning them when they offer their input, as you maintain your role as leader. At this point, they're still "under your wing" as you walk them through the process, but you're allowing them to participate in the process with you.

2. Collaborative Practice

This is where students get to apply the new concept in cooperative activities. This includes working with a partner, in small groups, or in larger groups.

Circulate the room to check for understanding as students work. Pause to clarify as needed. If you notice an area where many students are confused or struggling, stop and address this particular point with the entire class.

If necessary, go back and model a few additional examples followed by additional guided practice. You want to make sure your students are applying the concept correctly rather than practicing mistakes.

3. Independent Practice

Once students have had the opportunity to apply and practice the concept with their classmates through collaborative activities, it's time for them to apply and practice the concept on their own! This is where you can see if they really "got it."

Continue to circulate the room to check for understanding. You will notice which students have really grasped the concept and which students need you to take them a step back, offer more guided practice, and then gradually release them again to independent application of the concept.

6. Closure

This is where you "wrap it up." It's a quick synopsis of the lesson.

You may want to ask students to pair-share or to share out something they learned that period, or provide an example of the concept taught. Keep it short and sweet.

Example: "Today we learned about metaphors and similes. Tell your partner one example of a simile and one example of a metaphor."

7. Demonstration of Learning (Quick Assessment)

The demonstration of learning (D.O.L.) assessment evaluates whether or not your students met your lesson objectives. It aims to provide you with valuable feedback which should drive your instruction. Make sure the D.O.L. accurately reflects the learning objectives and allows your students to apply what they learned during the lesson.

The D.O.L. should always be completed independently without any teacher assistance. It should take most students no longer than five to ten minutes to complete and can be a simple written assignment. Some teachers call it an "exit ticket" to indicate that students must complete it before they exit the classroom.

Student performance on the D.O.L. tells you if you need to go back and reteach the same lesson the following day, or if your students are ready to move on to the next lesson.

Keep in Mind

Lesson Plans provide you and your students with a clear sense of direction in the classroom. Remember that they don't have to be extensive, drawn-out plans. They're meant to guide and assist you in maximizing classroom time.

Q.3 Explain the criterion for evaluation of laboratory work of physics students. Also justify the marks assigned and weight-age given to each task.

The laboratory is a unique learning environment that enables and consolidates "learning through doing". Assessing this learning can enhance students' conceptual understanding of the theory–practice relationship, their higher level reasoning skills and the development of their practical competence in laboratory work.

It is important that you clarify the specific objectives of the laboratory context for learning, for both students and assessors. These objectives should form the basis for all assessment decisions made. Learning outcomes that can be assessed using laboratory work include:

- technical and manipulative skills in using laboratory equipment, tools, materials, computer software
- an understanding of laboratory procedures, including health and safety, and scientific methods
- a deeper understanding of abstract concepts and theories gained by experiencing and visualising them as authentic phenomena
- the skills of scientific enquiry and problem-solving, including:
    - recognising and defining a problem
    - formulating hypotheses
    - designing experiments
    - collecting data through observation and/or experimentation
    - interpreting data
    - testing hypotheses
    - drawing conclusions
    - communicating processes, outcomes and their implications.
- the complementary skills of collaborative learning and teamwork in laboratory settings
- understanding, and being prepared for, future possible roles in laboratory-based work.

Assessment by laboratory learning is appropriate in contexts such as:

- undergraduate and postgraduate coursework in which laboratory tasks are a key feature
- professional laboratory student placement programs (work-integrated learning)
- capstone courses in which students undertake major projects requiring laboratory-based work.

While laboratory learning is most strongly associated with science and engineering, many of the same concepts are relevant to other clinical disciplines, such as law, medicine, social work and psychology.

Assessing laboratory learning shares some of the advantages of assessing authentic learning generally. Some of the benefits include that it:

- allows learners to extend and enhance their understanding of theoretical concepts by finding out how they operate in practical contexts
- gives learners self-confidence and a sense of achievement in successfully completing laboratory tasks
- provides opportunities for experiential learning through trial and error, which contributes to deeper understanding and reduces learner anxiety about making mistakes
- fosters learners' development of critical and independent reasoning through practical training in hypothesis testing, data collection and analysis
- encourages the development of interpersonal skills such as teamwork, peer teaching, negotiation and collaboration
- provides a relatively informal and collegial learning environment that makes it easier for quiet or shy students to contribute to learning activities
- develops the acquisition of specific skills and capabilities required in workplace settings relevant to the discipline
- allows teaching staff more opportunities to monitor learners in person and provide assistance and feedback that is timely and thus more educationally effective
- rewards responsible and ethical behavior, such as following safety procedures, helping others, punctuality and generally being a cooperative and reliable classmate
- where laboratory task design is more open-ended and flexible:
    - gives learners greater responsibility and autonomy in making decisions
    - increases motivation by allowing learners to follow personal interests and use their creativity.

Challenges

- In the laboratory, safety issues are paramount and operational costs high, especially in large undergraduate classes. Science and engineering educators may be reluctant to conduct assessments in the lab, preferring less risky formats, such as online quizzes and written reports of laboratory work.
- Students enrol in science-based courses for lots of different reasons. This can be challenging when you teach large undergraduate science and engineering cohorts. Many of your students won't be science majors, and this will influence the learning objectives significantly, and may be difficult to accommodate when you assess laboratory-based learning.
- Assessment design can be a problem. Laboratory-based learning usually has wide-ranging objectives, spanning practical and motor skills, broader understanding of concepts and theories, and higher level

thinking and reasoning skills of scientific enquiry. It's a challenge to devise assessment methods that capture student learning that:

  - is active (hands-on, motor skills) and reflective (post-hoc), and that
  - encompasses both tacit knowledge and knowledge that can be articulated more readily.

- Educators often consider the demonstration of basic practical skills in the laboratory to be a preliminary hurdle assessment (on the grounds of safety), but conducting such an assessment in a laboratory environment can expose students to risks and be a highly resource-intensive activity.
- Assessment in labs can be very time-consuming for students and staff, and resource-intensive. It can be difficult to keep assessment tasks well aligned. For example, although laboratory activities may be designed to foster independent and creative approaches to solving novel problems, the assessment tasks may be closed-ended and recipe-like, which limits their usefulness in assessing higher-level understanding and reasoning.
- Giving students the autonomy to design and carry out their own lab experiments creates many challenges and a heavy workload for technical and support staff, particularly in large classes.
- Assessments conducted in laboratories are typically confined to tightly time-limited sessions. This can disadvantage some students. Reasonable accommodations for students with disabilities can be challenging to arrange.
- Many students are reluctant to admit to mistakes, or to acknowledge that an experiment has failed, fearing that this will result in low grades. Unless you highlight the value of learning from both successes and failures, and reward such learning in assessment, students may be tempted to engage in fraudulent conduct. For example, they may alter experimental results to show a more successful outcome, or they may plagiarise.

Q.4 Identify different computer programs for teaching of physics. Also discuss the role of computer programs while imparting science instructions to distance learners.

Physics is said to be a difficult subject. Physics learning is not an easy task. There is strong evidence all over the world that physics students are not learning the concepts necessary for a good understanding of the physics world. Their learning of scientific facts remains in the classroom only. The computer is one of the most brilliant gifts of science having characteristics of speed, accuracy, reliability, and integrity. It can execute over a million instructions per second without any mistake. It can carry our calculation in just a few minutes that would require a month If carried out manually. The computational techniques have provided a friend and servant to science, technology, and industry. **In the present learning, process computers are being used for enhancing physics learning also. They can be used to analyze and visualize data, communicate results, run experiments and monitor equipment.** Computing can play an important and varied role in advancing physics learning. We point out the role of computational techniques namely Simulations, Multimedia, Virtual Reality,

Telematics, and computer-based labs which may deal with those difficulties and increase the learning process. Some good computer programs for learning physics exist. Emergent computational tools and new development in learning theories have contributed to change in education. But we are still in the middle of the change process. Although computers are not new to most physicists their use in physics teaching is not yet widespread. Some underlying reasons for this are discussed. The need for professional quality software is justified and contrasted with teaching programs developed in the past by academics. These packages, although valuable, are shown to have general problems which are normally associated with being too specific either in terms of hardware requirements or presentation style. Some of the most suitable teaching packages are found to be those that contain little specific information but support sophisticated data manipulations or the study of complex physical simulations in a simple way. Modern computers could not possibly exist if we had been forced to stick with this kind of "switch" technology. Thankfully, we were saved by the invention of the transistor. Transistors basically perform the same function as the old vacuum tubes, but the physical principles by which they operate are completely different, and as a result they can be built on the nanometer scale. Now, transistors are far from the only piece of technology in a modern computer that employs quantum mechanical principles. If you have a solid-state drive, for example, the process of writing to it uses quantum tunneling. But out of all of these amazing advances, transistors probably had the most visible impact on computer hardware.

Q.5 Suggest different techniques to handle individual differences in science classrooms. Which strategies should be adopted to teach visually impaired students?

"Because all students are capable learners, you as a teacher must demonstrate that all students are expected to fully participate in all activities. Sometimes you will want to offer options for students to choose from, but everyone should be involved in learning."

—Susan Winebrenner, author of Teaching Kids with Learning Difficulties in the Regular Classroom

The following are some creative teaching strategies you can use to teach students with different needs in the ways they learn best. It summarizes some of these methods that help to better understand and respond to these students

Differentiate instruction.

It's important to recognize that "fairness" in education doesn't mean that all children are taught in the exact same way. Instead it means accounting for the needs of individual students and adjusting the curriculum accordingly. Differentiation allows you to provide individualized instruction by changing the pace, level, or style of teaching to engage student strengths and interests. Students with mental health and learning disorders are not the only children who benefit from this instructional philosophy—all children in your classroom can achieve at higher levels when you are conscientious about providing instruction that fits how they learn best. Differentiating instruction includes, when appropriate, reducing assignments or extending deadlines to accommodate a child's abilities.

Capitalize on learning styles. Students learn in a number of different ways. Visual learners learn most effectively from visual information, while auditory learners learn best from verbal or audio presentations. Tactile-kinesthetic learners do well when touching or moving in some way as they take in information (experiential learning). While students can often learn to some degree in all of these different ways, many excel in one area so that instruction based on a particular style is much more effective than that of another. Deficits in one or more areas of learning can be particularly common in students with learning disabilities.

Incorporate multiple intelligences into curriculum. Students often have areas of learning in which they are particularly strong. These learning strengths can be engaged to help students succeed in the classroom and reach their full potential. The multiple intelligences are a framework of strengths outlined by Harvard psychologist Howard Gardner. They are linguistic, logical-mathematical, visual- spatial, musical-rythmic, bodily-kinesthetic, interpersonal, intrapersonal, and naturalist. Most students have strengths in one or two of these areas.

Capitalize on student interests. One of the best ways to motivate students is to incorporate their interests into the curriculum. As much as possible, allow students to choose the topics they'll report on in a paper or project. Also look to include interests in other smaller ways—such as in math word problems. Tying learning to interests is a potentially powerful way to reinforce core curriculum concepts.

Involve students in educational goals. Students perform best when they feel they are active participants, as opposed to passive subjects, in learning. Try to involve students in creating goals related to learning activities. Children with mental health and learning disorders may have a negative attitude toward schoolwork so incentives are required at the outset. Your goal ultimately should be to have students genuinely engaged in learning so that rewards become less important.

Use computerized instruction. Most students enjoy working with computers, which can stimulate their interest in schoolwork. A wide assortment of available programs from reading instruction to voice recognition software makes computerized instruction very relevant in helping students with special needs. Activities and games that incorporate material from content themes can reinforce concepts for visual and tactile learners.

Group students effectively. Group projects provide great opportunities for you to put together the talents of students in complementary ways. A child who struggles in one aspect of a subject may excel in another. Group students so that they can both showcase strengths and learn from peers. Also give careful consideration to the social dynamics of groups. Children who have mental health and learning disorders benefit from working with students who are especially kind, patient, and empathetic.

Consider outside placement options. Some children may have needs you simply cannot meet in the regular classroom. At these times, work with your school's specialists to ensure skills are developed in other settings. A child with a communication disorder might require intensive work with a speech language pathologist. An extremely disruptive student may need to spend part of the day in a program set up for children with serious emotional disorders.