Course: Foundations of Science Education (695)
Semester: Spring, 2022

ASSIGNMENT No. 2

Q. 1 Discuss the key features and importance of Gagne's hierarchy of learning.

This theory stipulates that there are several different types or levels of learning. The significance of these classifications is that each different type requires different types of instruction. Gagne identifies five major categories of learning: verbal information, intellectual skills, cognitive strategies, motor skills and attitudes. Different internal and external conditions are necessary for each type of learning. For example, for cognitive strategies to be learned, there must be a chance to practice developing new solutions to problems; to learn attitudes, the learner must be exposed to a credible role model or persuasive arguments.

Gagne suggests that learning tasks for intellectual skills can be organized in a hierarchy according to complexity: stimulus recognition, response generation, procedure following, use of terminology, discriminations, concept formation, rule application, and problem solving. The primary significance of the hierarchy is to identify prerequisites that should be completed to facilitate learning at each level. Prerequisites are identified by doing a task analysis of a learning/training task. Learning hierarchies provide a basis for the sequencing of instruction.

In addition, the theory outlines nine instructional events and corresponding cognitive processes:

1. Gaining attention (reception)
2. Informing learners of the objective (expectancy)
3. Stimulating recall of prior learning (retrieval)
4. Presenting the stimulus (selective perception)
5. Providing learning guidance (semantic encoding)
6. Eliciting performance (responding)
7. Providing feedback (reinforcement)
8. Assessing performance (retrieval)
9. Enhancing retention and transfer (generalization).

These events should satisfy or provide the necessary conditions for learning and serve as the basis for designing instruction and selecting appropriate media (Gagne, Briggs & Wager, 1992).

Application

While Gagne's theoretical framework covers all aspects of learning, the focus of the theory is on intellectual skills. The theory has been applied to the design of instruction in all domains (Gagner & Driscoll, 1988). In its original formulation (Gagne, 1 962), special attention was given to military training settings. Gagne (1987) addresses the role of instructional technology in learning.

Example

The following example illustrates a teaching sequence corresponding to the nine instructional events for the objective, Recognize an equilateral triangle:

1. Gain attention – show variety of computer generated triangles

2. Identify objective – pose question: "What is an equilateral triangle?"
3. Recall prior learning – review definitions of triangles
4. Present stimulus – give definition of equilateral triangle
5. Guide learning- show example of how to create equilateral
6. Elicit per formance – ask students to create 5 different examples
7. Provide feedback – check all examples as correct/incorrect
8. Assess performance- provide scores and remediation
9. Enhance retention/transfer – show pictures of objects and ask students to identify equilaterals

Gagne (1985, chapter 12) provides examples of events for each category of learning outcomes.

Principles

1. Different instruction is required for different learning outcomes.
2. Events of learning operate on the learner in ways that constitute the conditions of learning.
3. The specific operations that constitute instructional events are different for each different type of learning outcome.
4. Learning hierarchies define what intellectual skills are to be learned and a sequence of instruction

Q. 2 Define Idealism. Discuss significance of this philosophy for science education.

Idealism is a very old philosophical thought and it has exercised a potent influence on the mind of man throughout the ages. Even in modern times when people are not inclined towards accepting any dogmatic creed or philosophy, idealism has certain attractions which appeal to the human mind and thereby exercise a great influence on human thinking. In education the influence of idealism has gone a long way to restrict some of the radical thinking and establish the worth of the eternal ideals and values of life.

The word idealism is derived from two distinct sources-the idea and the ideal. Idea means true and testified knowledge. The word ideal stands for the perfected form of an idea or ideas. An idealist does not have considerations for material values of life. A thinker who idolizes 'Mind and Self' is an idealist. Idealism is one of the oldest schools of philosophy.

TYPES OF IDEALISM

(a) ABSOLUTE IDEALISM

It is the one type which has found its way into educational philosophy. This lays down that the heart of reality is to be found in thought or reason. Reason is absolute; in fact it is the absolute. Being absolute, it is also one i.e., monistic. Everything, thus, is interrelated and all contradictions reconciled. Furthermore the complete cause of any single occurrence involves the whole of reality. The cosmos is great thought process, and the absolute is god thinking. Everything happens as a result of the self-willed idea i. e. absolute. The absolute is already complete, and self-realized. Nature is the medium through which the absolute progressively reveals itself in external form. Mind of man however, is a part of the absolute whole. The absolute being the whole and education being a part thereof, it may be that study of the fragment may reveal important facts of the totality.

The centralistic approach to idealism on the whole has committed this educational philosophy to the prominent importance of consciousness. Mind is ultimately spiritual, not materialistic. Human nature is to be viewed, as more than a behaving organism, responding to the stimuli of its environment. Man is too atomistic. Idealism stresses certain wholeness. Nothing happens in any part of the system that does not affect the rest.

On religious and moral education, the definition of the absolute is unmistakably of theistic characteristics. Since the aim of education is the increasing realization of the absolute, all education appears tinged with religious significance. This includes moral education. Reason being the absolute, the universe is one of law and order. So too there is a oral law in the universe backed by the authority of the absolute. Thus lays an inescapable moral imperative on education.

(b) MODERN IDEALISM

It has given a different tune to educational philosophy. In this concept idealism more to do this idea as metal state. n this idealism might be called a philosophy of idealism. The `I` of idealism being interested for euphony. The knowledge one has of his environment is idea of it. The environment in itself cannot be known through intermediate idea of it. The environments in itself cannot be known directly. It can only be known through intermediate idea of human knower. From which the learner's knowledge takes, therefore, is bound to be in part the product of his human way of apprehending it. Such concepts are supplied by the mind of human learning.

FUNDAMENTAL PRINCIPLES OF IDEALISM

The fundamental principles of idealism are:

(1) TWO FORMS OF THE WHOLE WORLD

Idealism believes in two forms of the world- Spiritual world and Material world, Idealists gives more importance to spiritual world in comparison to the material world. They believe that spiritual world is real and the ultimate truth whereas the material world is transitory and moral. According to Horne- "Idealism holds that the order of the world is due to the manifestation in space and time of an eternal and spiritual reality."

(2) IDEAS ARE MORE IMPORTANT THAN OBJECT

According to Idealists, knowledge of mind and soul can be obtained through ideas only. Hence, they have given more importance to ideas over the objects and material or later. In the words of Plato "Ideas are of the ultimate cosmic significance. They are rather the essences or archetypes which give form to cosmos. These ideas are eternal and unchanging."

(3)IMPORTANCE OF MAN OVER NATUR

To Idealists, man is more important than material nature. It is because man can think and experience about material objects and material phenomena. Hence, the thinker or the one who experiences is more important than the object or the phenomena experienced. Man is endowed with intelligence and a sense of discrimination. Thus, he is not a slave of the environment as animals are but the moulds and transforms the environment for his own good and welfare of the society. In short, he creates his own world of virtue and his creativity achieves higher and higher levels of art in many areas.

(4)FAITH IN SPIRITUAL VALUES

According to Idealists, prime aim of life is to achieve spiritual values-Truth, beauty and goodness. These spiritual values are undying and permanent. The realization of these values is the realization of god. In the pursuit of these absolute values man rises higher and higher in the moral plane till he attains divinity. For the achievement of these spiritual values all the capacities of man are to be harnessed to the full. These capacities are- knowing, feeling and willing.

(5)IMPORTANCE OF PERSONALITY DEVELOPMENT

Idealists give much importance to the 'self' of the individual. Hence they insist upon the fullest development of the personality of an individual. According to them the development of personality means achievement of 'perfection'. Plato rightly speaks that each individual has an ideal self. He tries to develop that ideal 'self' more and more. This self-realization is the true sense of the term. It may be noted that self-realization means knowledge of the 'self' or soul. This self-realization can only be achieved in society. Hence, development of social qualities is very essential for self-realization as it expresses itself in the form of love, sympathy, fellow-feeling and co-operation for the good of all and discrimination among human beings on any basis of caste, creed, sex, race or status etc. It clears the fact that Idealism advocates the concept of universal education. In short Idealism believes in the welfare of whole human community.

(6)FULL SUPPORT TO THE PRINCIPLE OF UNITY IN DIVERSITY

Idealists give full support to the principle of Unity in Diversity. They believe that is of spiritual nature. This may be called Universal Consciousness or Divinity. This underlying divine force maintains the existence and working of all entities. Idealists call this power as God, the Supreme Force which is omnipotent and omnipresent.

IDEALISM AND AIMS OF EDUCATION

Idealism prescribes certain fundamental aims of education which are directly influenced by the aims and principles of life. In this context Ross puts forth the view, "The function of education is to help us in our exploration of the ultimate universal values so that truth of the universe may become our truth and give power to our life.'' Some of the important aims of education as laid down by idealists are given below

(1) SELF REALIZATION.

According to idealism man is the most beautiful creation of god-His grandest work. It lays great stress on the exaltation of human personality it is self-realization The aim of education is to develop the self of the individuals higher till self-realization is achieved It is in fact making actual or real the highest potentialities of the self.

(2) UNIVERSAL EDUCATION.

Education according to idealism should be universal in nature. The universe is regarded as a thought process. Education should be based on the teaching of Universal truth from the stand-point of rationality of the Universe

(3) SPIRITUAL DEVELOPMENT.

Idealists give greater importance to spiritual values in comparison with material attainments. According to Rusk, "Education must enable Mankind through its culture to enter more and more fully into the spiritual realm, and also enter more and more fully into the spiritual realm, and also enlarge the boundaries of spiritual realm".

(4)TRANSMISSION AND PROMOTION OF CULTURAL HERITAGE

The aim of idealistic education is the preservation ; enrichment and transmission of culture, Education must contribute to the development of culture .It should help in enlarging the boundaries of spiritual realm

(5)CULTIVATION OF MORAL VALUES

According to idealism, man is essentially a moral being. Therefore, moral, intellectual and aesthetic aspects of his personality should be promoted. According to Dr.Prem Nath "The process of education must lead to the deepest spiritual insight and to the highest moral and spiritual insight and to the highest moral and spiritual insight and to the highest moral and spiritual conduct ."

(6) PREPARATION FOR A HOLY LIFE

Idealism prepares an individual for a holy life. Froebel says."The object of education is the realization of a faithful, pure, inviolable and hence holy life.''

(7) DEVELOPMENT OF INTELLIGENCE AND RATIONALITY

Idealism wishes that education should develop the mind fully. It makes a person rational as well. Only the highly developed mind can understand the all pervading force. The idealists believe that education must help in the full evolution of mind , the emancipation of spirit, self realization and the realization of higher values of life and to train the whole man completely and fully for manhood and not some part of man.

IDEALISM AND CURRICULUM

While developing curriculum, idealists give more importance to thought, feelings, ideals and values than to the child and his activities. They firmly hold that curriculum should be concerned with the whole humanity and its experiences. It must consist of humanities.

The curriculum should give good mental experience of all types. So cognition (knowing) affecting (feeling) and conation (striving) should find due place. Sciences and art should be taught as fully integrated. Since the main aim of education according to the philosophy of idealism is to preserve and advance the culture of human race ,so subjects like Religion, Ethics, philosophy, History, Literature etc, should be provided in the curriculum. Healthy mind is found in healthy baby only. So health, hygiene, games and sports should find an important place in the curriculum.

IDEALISM AND METHODS OF TEACHING

Idealism has not prescribed specific methods of teaching. According to idealism, class-room is a temple of spiritual learning, a meeting place of human minds- a place for self education. For this no particular method has been suggested.However, the following methods have been advocated by different idealists:

- · Learning through reading
- · Learning through lecturing

- · Learning through discussion
- · Learning through imitation
- · Descrates employed the device of simple to complex

IDEALISM AND DISCIPLINE

Naturalism provides unrestricted freedom to the child whereas Idealism wants to keep the child under discipline. Idealists believe that there can be no spiritual development of the child without discipline. This leads to inner discipline. "The discipline is not to be imposed on pupils. The teacher has only to help them to develop self discipline and through that self knowledge"

Self-insight and self analysis are the main disciplinary factors. The main task of education is the cultivation of higher values of life through moral and religious education. It requires the teacher to present a good example and exercise lasting impact upon the pupil's mind. A teacher is an ideal person to be emulated by this pupil.

IDEALISM AND TEACHER

Idealism assigns a special role to the teacher. It considers teacher as a spiritual guide for the child. The teacher serves as a living model for the student. He sets the environment in which education takes place. He carries the child from darkness to light. He is to guide the student towards utmost possible perfection

Idealism regards the teacher as the priest of man's spiritual heritage. He is a co-worker with God in perfecting man. An idealist teacher is a philosopher, friend and guide. According to Gentle- A teacher is "a spiritual symbol of right conduct." He is thus, an indispensable necessity.

According to Froebel, the school is a garden, the teacher is a cautious gardener and the child is a tender plant. The plant can grow, no doubt, without help but the good gardener sees that the plant grows to the finest possible perfection. Through teacher's guidance the child can make his natural development into a process leading to perfection and beauty.

CONTRIBUTIONS OF IDEALISM TO EDUCATION

Idealistic philosophy in education emphasizes 'the exaltation of personality', which is the result of self-realization, achieved by spiritual knowledge, self-discipline and dignified teacher. Idealism assigns a very important place to the teacher who is respected as a guide, and philosopher. They emphasize the importance of moral and spiritual education and points out the values of humanities, social sciences, art and literature. It emphasizes man's perfection in various facets of life-physical, spiritual, intellectual, moral, esthetic and social.

EVALUATION OF IDEALISM

(1)The common criticism regarding Idealism is that it is an abstract and vague doctrine. It avoids the present realities and prepares the child for the next world.

(2) Idealism is concerned with the ultimate end of life. It avoids the real problems day to day living. Education should be such as to make individuals capable to solve the problems that confront them from time to time able to lead a happy and contented life.

(3) Idealism lays more emphasis on thinking and mental activities. This increases the importance of intellectualism unnecessarily.

(4) Idealistic education gives more importance to teacher in relation to the child. Modern psychology emphasizes the prime and central importance of child.

(5) Idealistic methods of teaching emphasize cramming and rote memory. In modern education, these methods are given little importance.

Q. 3 Deliberate on the social limitations for the successful execution of science for the development.

To do most any kind of research, scientists need money: to run studies, to subsidize lab equipment, to pay their assistants and even their own salaries. Our respondents told us that getting — and sustaining — that funding is a perennial obstacle.

Their gripe isn't just with the quantity, which, in many fields, is shrinking. It's the way money is handed out that puts pressure on labs to publish a lot of papers, breeds conflicts of interest, and encourages scientists to overhype their work.

In the United States, academic researchers in the sciences generally cannot rely on university funding alone to pay for their salaries, assistants, and lab costs. Instead, they have to seek outside grants. "In many cases the expectations were and often still are that faculty should cover at least 75 percent of the salary on grants," writes John Chatham, a professor of medicine studying cardiovascular disease at University of Alabama at Birmingham.

Grants also usually expire after three or so years, which pushes scientists away from long-term projects. Yet as John Pooley, a neurobiology postdoc at the University of Bristol, points out, the biggest discoveries usually take decades to uncover and are unlikely to occur under short-term funding schemes.

Outside grants are also in increasingly short supply. In the US, the largest source of funding is the federal government, and that pool of money has been plateauing for years, while young scientists enter the workforce at a faster rate than older scientists retire.

Truly novel research takes longer to produce, and it doesn't always pay off. A National Bureau of Economic Research working paper **found** that, on the whole, truly unconventional papers tend to be less consistently cited in the literature. So scientists and funders **increasingly shy away** from them, preferring short-turnaround, safer papers. But everyone suffers from that: the NBER report found that novel papers also occasionally lead to big hits that inspire high-impact, follow-up studies.

"I think because you have to publish to keep your job and keep funding agencies happy, there are a lot of (mediocre) scientific papers out there ... with not much new science presented," writes Kaitlyn Suski, a chemistry and atmospheric science postdoc at Colorado State University.

Another worry: When independent, government, or university funding sources dry up, scientists may feel compelled to turn to industry or interest groups eager to generate studies to support their agendas.

Right now there are arguably too many researchers chasing too few grants. Or, as a 2014 **piece** in the Proceedings of the National Academy of Sciences put it: "The current system is in perpetual disequilibrium, because it will inevitably generate an ever-increasing supply of scientists vying for a finite set of research resources and employment opportunities."

"As it stands, too much of the research funding is going to too few of the researchers," writes Gordon Pennycook, a PhD candidate in cognitive psychology at the University of Waterloo. "This creates a culture that rewards fast, sexy (and probably wrong) results."

One straightforward way to ameliorate these problems would be for governments to simply increase the amount of money available for science. (Or, more controversially, decrease the number of PhDs, but we'll get to that later.) If Congress boosted funding for the NIH and National Science Foundation, that would take some of the competitive pressure off researchers.

But that only goes so far. Funding will always be finite, and researchers will never get blank checks to fund the risky science projects of their dreams. So other reforms will also prove necessary.

One suggestion: Bring more stability and predictability into the funding process. "The NIH and NSF budgets are subject to changing congressional whims that make it impossible for agencies (and researchers) to make long term plans and commitments," M. Paul Murphy, a neurobiology professor at the University of Kentucky, writes. "The obvious solution is to simply make [scientific funding] a stable program, with an annual rate of increase tied in some manner to inflation."

Another idea would be to change how grants are awarded: Foundations and agencies could fund specific people and labs for a period of time rather than individual project proposals. (The Howard Hughes Medical Institute already does this.) A system like this would give scientists greater freedom to take risks with their work.

Alternatively, researchers in the journal mBio recently **called for** a lottery-style system. Proposals would be measured on their merits, but then a computer would randomly choose which get funded.

"Although we recognize that some scientists will cringe at the thought of allocating funds by lottery," the authors of the mBio piece write, "the available evidence suggests that the system is already in essence a lottery without the benefits of being random." Pure randomness would at least reduce some of the perverse incentives at play in jockeying for money.

There are also some ideas out there to minimize conflicts of interest from industry funding. Recently, in PLOS Medicine, Stanford epidemiologist John Ioannidis suggested that pharmaceutical companies **ought to pool the money** they use to fund drug research, to be allocated to scientists who then have no exchange with industry during study design and execution. This way, scientists could still get funding for work crucial for drug approvals — but without the pressures that can skew results.

These solutions are by no means complete, and they may not make sense for every scientific discipline. The daily incentives facing biomedical scientists to bring new drugs to market are different from the incentives facing geologists trying to map out new rock layers. But based on our survey, funding appears to be at the root of many of the problems facing scientists, and it's one that deserves more careful discussion.

Scientists are ultimately judged by the research they publish. And the pressure to publish pushes scientists to come up with splashy results, of the sort that get them into prestigious journals. "Exciting, novel results are more publishable than other kinds," says **Brian Nosek**, who co-founded the Center for Open Science at the University of Virginia.

The problem here is that truly groundbreaking findings simply don't occur very often, which means scientists face pressure to game their studies so they turn out to be a little more "revolutionary." (Caveat: Many of the respondents who focused on this particular issue hailed from the biomedical and social sciences.)

Some of this bias can creep into decisions that are made early on: choosing whether or not to randomize participants, including a control group for comparison, or controlling for certain confounding factors but not others. Many of our survey respondents noted that perverse incentives can also push scientists to cut corners in how they analyze their data.

"I have incredible amounts of stress that maybe once I finish analyzing the data, it will not look significant enough for me to defend," writes Jess Kautz, a PhD student at the University of Arizona. "And if I get back mediocre results, there's going to be incredible pressure to present it as a good result so they can get me out the door. At this moment, with all this in my mind, it is making me wonder whether I could give an intellectually honest assessment of my own work."

Increasingly, meta-researchers (who conduct research on research) are realizing that scientists often do find little ways to hype up their own results — and they're not always doing it consciously. Among the most famous examples is a technique called **"p-hacking,"** in which researchers test their data against many hypotheses and only report those that have statistically significant results.

In a recent **study**, which tracked the misuse of p-values in biomedical journals, meta-researchers found "an epidemic" of statistical significance: 96 percent of the papers that included a p-value in their abstracts boasted statistically significant results.

That seems awfully suspicious. It suggests the biomedical community has been chasing statistical significance, potentially giving dubious results the appearance of validity through techniques like p-hacking — or simply suppressing important results that don't look significant enough. Fewer studies share **effect sizes** (which arguably gives a better indication of how meaningful a result might be) or discuss measures of uncertainty.

"The current system has done too much to reward results," says Joseph Hilgard, a postdoctoral research fellow at the Annenberg Public Policy Center. "This causes a conflict of interest: The scientist is in charge of evaluating the hypothesis, but the scientist also desperately wants the hypothesis to be true."

The consequences are staggering. An estimated $200 billion — or the equivalent of 85 percent of global spending on research — is routinely **wasted** on poorly designed and redundant studies, according to meta-researchers who have analyzed inefficiencies in research. We know that as much as **30 percent** of the most influential original medical research papers later turn out to be wrong or exaggerated.

Q. 4 Discuss Constructivism as a Referent in Teaching Science.

Constructivism is an epistemology, a theory of knowledge used to explain how we know what we know. We believe that a constructivist epistemology is useful to teachers if used as a referent; that is, as a way to make sense of what they see, think, and do. Our research indicates that teacher's beliefs about how people learn (their personal epistemology), whether verbalized or not, often help them make sense of, and guide, their practice. The epistemology that is dominant in most educational settings today is similar to objectivism. That is to say, most researchers view knowledge as existing outside the bodies of cognizing beings, as beings separate from knowing and knowers. Knowledge is "out there," residing in books, independent of a thinking being. Science is then conceptualized as a search for truths, a means of discovering theories, laws, and principles associated with reality. Objectivity is a major component of the search for truths which underlie reality; learners are encouraged to view objects, events, and phenomenon with an objective mind, which is assumed to be separate from cognitive processes such as imagination, intuition, feelings, values, and beliefs (Johnson, 1987). As a result, teachers implement a curriculum to ensure that students cover relevant science content and have opportunities to learn truths which usually are documented in bulging textbooks. The constructivist epistemology asserts that the only tools available to a knower are the senses. It is only through seeing, hearing, touching, smelling, and tasting that an individual interacts with the environment. With these messages from the senses the individual builds a picture of the world.

Therefore, constructivism asserts that knowledge resides in individuals; that knowledge cannot be transferred intact from the head of a teacher to the heads of students. The student tries to make sense of what is taught by trying to fit it with his/her experience.

Consequently, words are not containers whose meanings are in the words itself, they are based on the constructions of individuals. We can communicate because individual's meanings of words only have to be compatible with the meanings given by others. If a situation occurred in which your meaning of a word no longer sufficed, you could change the meaning of the word. Using constructivism as a referent, teachers often use problem-solving as a learning strategy; where learning is defined as adaptations made to fit the world they experience. That is, to learn, a person's existing conceptions of the world must be unreliable, inviable. When one's conceptions of the world are inviable one tries to make sense out of the situation based on what is already known (i.e. Prior knowledge is used to make sense of data perceived by the senses). Other persons are part of our experiential world, thus, others are important for meaning making.

"Others" are so important for constructivists that cooperative learning is a primary teaching strategy. A cooperative learning strategy allows individuals to test the fit of their experiential world with a community of others. Others help to constrain our thinking. The interactions with others cause perturbations, and by resolving the perturbations individuals make adaptations to fit their new experiential world.

Experience involves an interaction of an individual with events, objects, or phenomenon in the universe; an interaction of the senses with things, a personal construction which fits some of the external reality but does not provide a match. The senses are not conduits to the external world through which truths are conducted into the body. Objectivity is not possible for thinking beings. Accordingly, knowledge is a construction of how the world works, one that is viable in the sense that it allows an individual to pursue particular goals. Thus, from a constructivist perspective, science is not the search for truth. It is a process that assists us to make sense of our world. Using a constructivist perspective, teaching science becomes more like the science that scientists do it is an active, social process of making sense of experiences, as opposed to what we now call "school science." Indeed, actively engaging students in science (we have all heard the call for "hands-on, minds-on science") is the goal of most science education reform. It is an admirable goal, and using constructivism as a referent can possibly assist in reaching that goal.

Driver (1989) has used a constructivist epistemology as a referent in her research on children's conceptions of science. Children's prior knowledge of phenomena from a scientific point of view differs from the interpretation children construct; children construct meanings that fit their experience and expectations. This can lead children to oftentimes construct meanings different from what was intended by a teacher. Teachers that make sense of teaching from an objectivist perspective fail to recognize that students solve this cognitive conflict by separating school science from their own life experiences. In other words, students distinguish between scientific explanations and their "real world" explanations (the often cited example-that forces are needed to keep a ball in motion versus Newton's explanation is one such example). Children's conceptions are their constructions of reality, ones that are viable in the sense that they allow a child to make sense of his/her environment. By using a constructivist epistemology as a referent teachers can become more sensitive to children's prior knowledge and the processes by which they make sense of phenomena.

The teaching practices of two teachers at City Middle School may best illustrate how practice can be influenced by making sense of teaching and learning from constructivist-and objectivist-oriented perspective. To Bob, science was a body of knowledge to be learned. His job was to "give out" what he (and the textbook) knew about science to his students. Thus the learning environment Bob tried to maintain in his classroom facilitated this transfer of knowledge; the desks were neatly in rows facing Bob and the blackboard. Lectures and assignments from the text were given to students. Bob tried to keep students quiet and working all during the class period to ensure that all students could "absorb" the science knowledge efficiently. Another consequence of Bob's notion of teaching and learning was his belief that he had so much cover that he had no time for laboratory activities.

On the other hand, John made sense of teaching and learning from a constructivist perspective. John's classes were student-centered and activity-based. Typically in his high school classes, John introduced students to different science topics with short lectures, textbook readings, and confirmatory laboratories. After the introduction John would ask students what interested them about the topic and encouraged them to pursue and test these ideas. Students usually divided themselves into groups and then, conducted a library research, formulated questions/problems, and procedures to test the questions/problems. In other words, the students were acting as scientists in the classroom. Like Bob, John taught a sixth grade class previously, and also taught students about friction. Included in John's lessons were activities to "get the students involved." Students rubbed their hands together with and without a lubricant so that they could see the purpose of motor oil in engines.

Q. 5 What are the substantial outcomes of revolution in science teaching? Discuss.

Scientific Revolution, drastic change in scientific thought that took place during the 16th and 17th centuries. A new view of nature emerged during the Scientific Revolution, replacing the Greek view that had dominated science for almost 2,000 years. Science became an autonomous discipline, distinct from both philosophy and technology, and it came to be regarded as having utilitarian goals. By the end of this period, it may not be too much to say that science had replaced Christianity as the focal point of European civilization. Out of the ferment of the Renaissance and Reformation there arose a new view of science, bringing about the following transformations: the reeducation of common sense in favour of abstract reasoning; the substitution of a quantitative for a qualitative view of nature; the view of nature as a machine rather than as an organism; the development of an experimental, scientific method that sought definite answers to certain limited questions couched in the framework of specific theories; and the acceptance of new criteria for explanation, stressing the “how” rather than the “why” that had characterized the Aristotelian search for final causes.

The growing flood of information that resulted from the Scientific Revolution put heavy strains upon old institutions and practices. It was no longer sufficient to publish scientific results in an expensive book that few could buy; information had to be spread widely and rapidly. Natural philosophers had to be sure of their data, and to that end they required independent and critical confirmation of their discoveries. New means were created to accomplish these ends. Scientific societies sprang up, beginning in Italy in the early years of the 17th century and culminating in the two great national scientific societies that mark the zenith of the Scientific Revolution: the Royal Society of London for Improving Natural Knowledge, created by royal charter in 1662, and the Académie des Sciences of Paris, formed in 1666. In these societies and others like them all over the world, natural philosophers could gather to examine, discuss, and criticize new discoveries and old theories. To provide a firm basis for these discussions, societies began to publish scientific papers. The old practice of hiding new discoveries in private jargon, obscure language, or even anagrams gradually gave way to the ideal of universal comprehensibility. New canons of reporting were devised so that experiments and discoveries could be reproduced by others. This required new precision in language and a willingness to share experimental or observational methods. The failure of others to reproduce results cast serious doubts upon the original reports. Thus were created the tools for a massive assault on nature’s secrets.

The Scientific Revolution began in astronomy. Although there had been earlier discussions of the possibility of Earth’s motion, the Polish astronomer Nicolaus Copernicus was the first to propound a comprehensive heliocentric theory equal in scope and predictive capability to Ptolemy's geocentric system. Motivated by the desire to satisfy Plato's dictum, Copernicus was led to overthrow traditional astronomy because of its alleged violation of the principle of uniform circular motion and its lack of unity and harmony as a system of the world. Relying on virtually the same data as Ptolemy had possessed, Copernicus turned the world inside out, putting the Sun at the centre and setting Earth into motion around it. Copernicus's theory, published in 1543, possessed a qualitative simplicity that Ptolemaic astronomy appeared to lack. To achieve comparable levels of quantitative precision, however, the new system became just as complex as the old. Perhaps the most revolutionary aspect of Copernican astronomy lay in Copernicus's attitude toward the reality of his theory. In contrast to Platonic instrumentalism, Copernicus asserted that to be satisfactory astronomy must describe the real, physical system of the world.

The reception of Copernican astronomy amounted to victory by infiltration. By the time large-scale opposition to the theory had developed in the church and elsewhere, most of the best professional astronomers had found some aspect or other of the new system indispensable. Copernicus's book De revolutionibus orbium coelestium libri VI ("Six Books Concerning the Revolutions of the Heavenly Orbs"), published in 1543, became a standard reference for advanced problems in astronomical research, particularly for its mathematical techniques. Thus, it was widely read by mathematical astronomers, in spite of its central cosmological hypothesis, which was widely ignored. In 1551 the German astronomer Erasmus Reinhold published the Tabulae prutenicae ("Prutenic Tables"), computed by Copernican methods. The tables were more accurate and more up-to-date than their 13th-century predecessor and became indispensable to both astronomers and astrologers. During the 16th century the Danish astronomer Tycho Brahe, rejecting both the Ptolemaic and Copernican systems, was responsible for major changes in observation, unwittingly providing the data that ultimately decided the argument in favour of the new astronomy. Using larger, stabler, and better calibrated instruments, he observed regularly over extended periods, thereby obtaining a continuity of observations that were accurate for planets to within about one minute of arc—several times better than any previous observation. Several of Tycho's observations contradicted Aristotle's system: a nova that appeared in 1572 exhibited no parallax (meaning that it lay at a very great distance) and was thus not of the sublunary sphere and therefore contrary to the Aristotelian assertion of the immutability of the heavens; similarly, a succession of comets appeared to be moving freely through a region that was supposed to be filled with solid, crystalline spheres. Tycho devised his own world system—a modification of Heracleides'—to avoid various undesirable implications of the Ptolemaic and Copernican systems.

The battle for Copernicanism was fought in the realm of mechanics as well as astronomy. The Ptolemaic–Aristotelian system stood or fell as a monolith, and it rested on the idea of Earth's fixity at the centre of the cosmos. Removing Earth from the centre destroyed the doctrine of natural motion and place, and circular motion of Earth was incompatible with Aristotelian physics.

Galileo's contributions to the science of mechanics were related directly to his defense of Copernicanism. Although in his youth he adhered to the traditional impetus physics, his desire to mathematize in the manner of Archimedes led him to abandon the traditional approach and develop the foundations for a new physics that was both highly mathematizable and directly related to the problems facing the new cosmology. Interested in finding the natural acceleration of falling bodies, he was able to derive the law of free fall (the distance, s, varies as the square of the time, t^2). Combining this result with his rudimentary form of the principle of inertia, he was able to derive the parabolic path of projectile motion. Furthermore, his principle of inertia enabled him to meet the traditional physical objections to Earth's motion: since a body in motion tends to remain in motion, projectiles and other objects on the terrestrial surface will tend to share the motions of Earth, which will thus be imperceptible to someone standing on Earth.