CHAPTER 2

THEORETICAL OVERVIEW

2.1 Perspectives on Instructional Packages

2.2 Perspectives on Multimedia Instructional Packages

2.3 Perspectives on Solid Geometry
Introduction

Discoveries and inventions never exist, until it has a theoretical base. Without a deep overview on the theory part of a concept, any study is incomplete and irrelevant. A theory describes the relationship among key variables for the purpose of explaining a current state or predicting future occurrences. It is primarily concerned with explanation and therefore focuses on determining cause-effect relationship.

This chapter of the research report deals with perspectives on the major constructs in the present study. It is organised in three sections, viz.

2.1 Perspectives on Instructional Packages
2.2 Perspectives on Multimedia Instructional Packages
2.3 Perspectives on Solid Geometry

Each section is detailed below.

2.1 Perspectives on Instructional Packages

An Instructional Package is a collection of materials to bring into effect specialised learning outcomes. It is a document containing all that is necessary for a learner to attain one or more specific objectives. It is to enable students to develop their knowledge through integration of theoretical and practical material. An instructional package includes materials to be read and looked at, to work with and to undertake. An instructional package should consist of the following.

- Clear statement of objectives.
- Meaningful language input, illustrations, summaries, and translations.
- Exercise materials and activities.
- Flexibility of materials.
- Clear learning instructions.
- Feedback and Testing.

Developing an Instructional Package

Designing an effective instructional plan requires some systematic planning taken into account, some critical issues which may be referred to as elements of instructional designs. Instructional design is the practice of
creating instructional experiences which make the acquisition of knowledge and skill more efficient, effective, and appealing. The process consists broadly of determining the current state and needs of the learner, defining the end goal of education, and creating some intervention to assist in the transition. Ideally the process is informed by pedagogically and andragogically tested theories of learning and may take place in student-only, teacher-led or community-based settings. The outcome of this instruction may be directly observable and scientifically measured or completely hidden and assumed. Instructional design model can also be referred to as the systematic process of planning and validating instruction for use, a good model should run right from the preparatory level to the evaluation level. Adegbija (2007) opined that a good model for instructional planning should be cyclic and dynamic in nature. Some known Models to develop Instructional Packages are.

I. The ADDIE Model
II. The ASSURE Model
III. Gerlach and Ely Model
IV. Dick and Carey Systems Approach Model
V. Kemp’s Model
VI. Gagne’s Model
VII. Kirk Patrick Evaluation Model

I. The ADDIE Model

The ADDIE Model of instructional design is actually a framework that lists the generic process traditionally used by instructional and training developers (Morrison, 2010). The ADDIE Model revolves around five stages, the first letter of each stage forming the acronym – ADDIE. The five stages of the ADDIE Model are Analysis, Design, Development, Implementation, and Evaluation. The ADDIE Model represents a dynamic, flexible guideline for building effective training and performance support tools.

The ADDIE model was initially developed by Florida State University to explain the process involved in the formulation of an instructional system development (ISD) programme for military inter service curriculum
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development activity (Branson et al, 1975). The model originally contained several steps under each of its five original phases, whose completion was expected before movement to the next phase. Over the years, the steps were revised and eventually the model itself became more dynamic and interactive than its original hierarchical rendition.

Phases of ADDIE Model of Instructional Design
The details of five phases of ADDIE Model follow.

Phase 1. Analysing

In the analysis phase, the instructional problem is clarified, the instructional goals and objectives are established, and the learning environment and the learner's existing knowledge and skills are identified. Given below are some of the questions addressed during the analysis phase:

- Who are the learners and what are their characteristics?
- What is the desired new behavioural outcome?
- What types of learning constraints exist?
- What are the delivery options?
- What are the pedagogical considerations?
- What are the Adult Learning Theory considerations?
- What is the timeline for project completion?

Phase 2. Designing

The design phase deals with learning objectives, assessment instruments, exercises, content, subject matter analysis, lesson planning and media selection. The design phase should be systematic and specific. Systematic means a logical, orderly method of identifying, developing and evaluating a set of planned strategies targeted for attaining the project's goals. Specific means each element of the instructional design plan needs to be executed with attention to details. The steps involved in the design phase are:

- Document the project's instructional, visual and technical design strategy.
- Apply instructional strategies according to the intended behavioural outcomes by domains of learning.
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- Design the user interface and/or user experience.
- Create prototype.
- Apply visual design (graphic design)

**Phase 3. Developing**

Based on the designing phase, content, assignments, assessments, and course structure are built. The development phase is where instructional designers and developers create and assemble the content assets that were blueprinted in the design phase. In this phase, storyboards and graphics are designed. If e-learning is involved, programmers develop and/or integrate technologies. The project is reviewed and revised according to the feedback received.

**Phase 4. Implementing**

During the implementation phase, a procedure for training the facilitators and the learners is developed. The training facilitators should cover the course curriculum, learning outcomes, method of delivery, and testing procedures. Preparation of the learners includes training them on new tools (software or hardware) and student registration. Implementation is also evaluation of the design. This is also the phase where the facilitator ensures that the books, hands-on equipment, tools, CD-ROMs and software are in place, and that the learning application or website is functional. That is, the implementation phase includes

- Overview of course expectations
- Initiation of instruction
- Interaction
- Asking for feedback early on (formative evaluation)

**Phase 5. Evaluating**

The evaluation phase consists of two parts: Student Evaluation and Evaluation of Implementation phase. Evaluation asks the following questions.

- Did the students achieve expected learning outcomes?
- What have you learned?
- How can you make the course better?
The ADDIE Model of Instructional Design is presented in Figure 2.1.

II. The ASSURE Model

The ASSURE Model is an Instructional System Design process that can be used by teachers and trainers to design and develop the most appropriate learning environment for their students. This process can be used in writing lesson plans and improving teaching and learning. The ASSURE model incorporates Robert Gagne’s events on instruction to assure effective use of media in instruction.

The six stages are of the Model are:

i. Analyse Learners
ii. State the Standard and the Objectives
iii. Select Strategies, Technology, Media and Materials
iv. Utilize Technology, Media and Materials
v. Require Learners’ Participation
vi. Evaluate and Revise

Stage i: Analyse Learners

To start with, ASSURE looks at the learners in detail. There is no plan or design of instruction that is effective unless the designer first looks at the learners. A good teacher or instructional planner/designer should analyse the
learners’ characteristics. The first step in planning is to specifically identify the audience. The audience can be students, new teachers, members of an organization, a youth group etc. The audience can be analysed in terms of their general characteristics (grade level, age, sex, mental, emotional, physical or social problems, socio-economic status etc.) and specific entry competencies (prior knowledge, skills, and attitudes about the topic), and learning styles (visual, musical, verbal, logical, etc.).

**Stage ii: State Standard and Objectives**

The next step in planning is to specifically state the objectives for the instructional experience. Objectives are the learning outcomes, i.e. the products that students get out of the lesson. Hence, they must be stated in behavioural terms of what the learner (not the teacher or presenter) will be able to do as a result of instruction. The Objectives typically contain four basic parts:

- Who are the Audience?
- Behaviour to be demonstrated
- Conditions under which the behaviour will be observed
- Degree to which the learned skills are to be mastered

**Stage iii: Select Strategies, Technology, Media and Materials**

Once the instructor know the audience and get a clear idea of what they should get out of the lesson, then it is time to select the appropriate method for the given learning task, select available materials, modify existing materials, or design new materials to help accomplish this task.

**Stage iv: Utilize Technology, Media and Materials**

The instructor must know how the technology, media and materials must be used to carry out the method(s). It is important to preview the materials before using them. If the instructor decides to use electronic equipment, he should practice using the equipment in advance to make sure that everything works well. An alternate plan to substitute for the equipment must be framed in advance so as to cope up in the event of a malfunction in the working of the decided equipment. It is also important to practice the lesson itself before it is implemented. The room must be prepared and the necessary equipment and
facilities readied. Learners should be prepared for the learning experience. Then, expose the instructional experience.

Stage v: Require Learners’ Participation

It is important to note that students learn best when they are actively involved in the learning experience. Whatever is the teaching strategy, it is important to incorporate questions and answers, discussions, group work, hands-on activities, and other ways of getting students actively involved in the learning of the content. One should avoid lecturing for lengthy periods. It is very important to listen to the audience and allow them to become aware of the content. Allow them to construct knowledge as opposed to trying to "teach" them knowledge. Feedback must be provided before any type of evaluation is administered.

Stage vi: Evaluate and Revise

This last stage is often overlooked but is the most important among all. After instruction, the instructor must evaluate the entire instructional process. He must reflect upon the lesson, the stated objectives, the instructional strategy, the instructional materials, and the assessment to determine if the elements of the lesson were effective or if one or more of them need to be changed. If there are discrepancies between what were intended and what actually happened during the lesson, appropriate revisions are to be made before using the lesson again.

The ASSURE Model of Instructional Design is presented in Figure 2.2.
III. Gerlach and Ely Model

The Gerlach and Ely Model is a classroom model created by Vernon S. Gerlach and Donald P. Ely, in 1980. They decided that there was a great need for school teachers to have a comprehensive overview of teaching and learning. For this reason, they determined ten most necessary instructional elements and created a step-by-step guidance for instructional planning. Gerlach and Ely Model was constructed based on two rationales: The systematic approach and the pragmatic approach. Throughout the Model, the role of the teacher is that of a coordinator of learning resources rather than that of a traditional presenter of information or knowledge. According to Gerlach and Ely (1980), this Model has stood the test of time and serves the classroom teacher well.
The ten steps of the Model are:

i) **Specification of instructional goals or objectives:** This is the first element itemized by Gerlach and Ely. In this stage, the teacher lists the objectives to be achieved at the end of the lesson, that is, the intended learning outcome.

ii) **Specification/Selection of Content:** The content is the total body of knowledge that the teacher intends to impart to the learners. The teacher carefully selects the content and the learner’s characteristics in order to address their needs, then disseminates to the learners using a specific methodology.

iii) **Assessment of Learner’s Entry Behaviour/ Previous Knowledge:** The teacher assesses the students’ previous knowledge by asking questions on their previous experience relating to the new topic. This helps him to start his teaching from known to unknown and from simple concepts to complex ones, also from empirical to abstract.

iv) **Determination of Instructional Strategy:** The teacher determines and deploys the most suitable instructional technique that suits the learner’s characteristics, subject, and content.

v) **Organization of Learners into Groups:** The teacher divides the learners into groups and allots activities for them.

vi) **Allocation of Time:** The teacher creates a regular timing schedule for each group, in order to supervise, coordinate, direct and inspect the activities of each group.

vii) **Allocation of Learning Space:** The teacher creates a conducive learning environment for each group, such that they can work at their own pace simultaneously.

viii) **Selection of Appropriate Instructional Material or Resources:** The teacher selects suitable materials to aid the learning. The teacher can use the adaptive, imitative or creative approach in designing his own instructional material to suit its purpose.

ix) **Evaluation of Instructional Outcome or Performance:** The teacher appraises the learners’ learning outcome by asking questions based on his predetermined instructional objectives as stated in step i.
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x) **Analyses of Feedback/Responses:** The result of the evaluation is compared with the expected learning outcome (stated objectives). If it meets the expectation, the teacher moves on to the next topic/content or otherwise carefully re-examines the objectives and starts all over.

Thus Gerlach and Ely Model is a cyclic process, just like the ADDIE and ASSURE Models. The Gerlach and Ely Model of instructional design is diagrammatically presented in Figure 2.3.

![Figure 2.3 Gerlach and Ely Model of Instructional Design](image)

**IV. Dick and Carey Systems Approach Model**

The Dick and Carey Systems Approach Model was originally published in 1978 by Walter Dick and Lou Carey in their book entitled, ‘The Systematic Design of Instruction’. They made a significant contribution to the instructional design field by championing a systems view of instruction as opposed to viewing instruction as a sum of isolated parts. The Model addresses instruction as an entire system, focusing on the interrelationship among context, content, learning and instruction. Components such as the instructor, learners, materials, instructional activities, delivery system, and learning and performance environments interact with each other and work together to bring about the desired student learning outcomes.
The components of the Dick and Carey Systems Approach Model are as follows.

i) Identify instructional goals: goal statements require a skill, knowledge or attitude that a learner is expected to acquire.

ii) Conduct instructional analysis: identify what a learner must recall and identify what learner must be able to do to perform particular task.

iii) Analyse learners and contexts: identify general characteristics of the target audience including prior skills and prior experience, identify characteristics directly related to the skill to be taught and analyse the performance and learning settings.

iv) Write performance objectives: objectives consist of description of the behaviour, the condition and criteria that will be used to judge learner’s performance.

v) Develop assessment instruments: entry behaviour testing, pre testing, post testing, practice items or problems.

vi) Develop instructional strategy: plan about pre instructional activities, content presentation, and learner participation.

vii) Develop and select instructional materials

viii) Design and conduct formative evaluation of instruction: try to identify areas of the instructional materials that are in need of improvement.

ix) Revise instruction: to identify poor test items and improper instructional techniques.

x) Design and conduct summative evaluation

The Dick and Carey Systems Approach Model of Instructional Design is presented in Figure 2.4.
V. Kemp’s Model

Jerold Kemp’s Model defines nine different components and at the same time adopts a continuous implementation or evaluation model. Kemp adopts a wide view and the overall shape of his Model conveys the design, development and assessment to ensure effective instruction. This Model is systematic, and nonlinear, and particularly useful for developing instructional programmes that blend technology, pedagogy and content so as to deliver effective, reliable and efficient learning.

The nine key elements of Kemp’s Model are:

i) Identify instructional problems and specify goals for designing an instructional programme.

ii) Examine learner characteristics that should receive attention during planning.

iii) Identify subject content and analyse task components related to stated goals and purposes.

iv) State instructional objectives for the learner.

v) Sequence content within each instructional unit for logical learning.

vi) Design instructional strategies so that each learner can master the objectives.

vii) Plan the instructional message and delivery.
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viii) Develop evaluation instruments to assess objectives.
ix) Select resources to support instruction and learning activities.

Kemp’s Model of Instructional Design is presented as Figure 2.5.

![Kemp's Model of Instructional Design](image)

**Figure 2.5**  
Kemp’s Model of Instructional Design

VI. Gagne’s Model

Robert Gagne’s Model focuses on the outcomes or behaviours resulting from training. Gagne is considered as the foremost contributor to systematic approach to instructional design and training. Gagne’s Model consists of nine steps called events of instruction, which correlate to and address the conditions of learning. According to Gagne, Walter, and Katherine (1992), the nine steps of instruction are:

i) Gain attention vii) Provide feedback
ii) Inform learner of objectives viii) Assess performance
iii) Stimulate recall of prior learning ix) Enhance retention transfer.
iv) Present stimulus material
v) Provide learner guidance
vi) Elicit performance
VII. Kirkpatrick Evaluation Model

Donald Kirkpatrick’s Evaluation Model is the most widely used and popular model for the evaluation of training and learning. The four levels of Kirkpatrick’s evaluation are:

i) Reactions: what they thought and felt about the training.

ii) Learning: the resulting increase in knowledge or capability

   Transfer: extent of behaviour and capability improvement

   Results: the effect on the environment resulting from trainee’s performance.

The Kirkpatrick Evaluation Model of Instructional Design is presented in Figure 2.7.
2.2 Perspectives on Multimedia Instructional Packages

In the last two decades, due to the advent of computer technologies, information delivery has got new meaning. In the past, most teaching depended almost entirely on verbal communication between the teacher and the student, or on written communication to the student from printed material. Although these communication channels continue to play important roles in the learning process, today’s students are learning facts, skills and attitudes from pictures, television, programmed lessons and other media. Once technology enters the school building, dramatic renovations begin. With the technological magic touch, a simple classroom turns into a systematized learning centre. Development, access and transfer of text, as well as sound and video data have given a unique face to classrooms, libraries and training and resource centres in the form of interactive multimedia learning.

There have been many experiments and innovations in the field of education and training regarding knowledge delivery. From face-to-face to verbal education, different technologies have played great roles at different times. Technology refers to the techniques as also the technical contrivances. A systematic way of applying the techniques to achieve an objective is as important as the use of technical equipment for the same. The use of newer terms ‘educational technology’ or ‘instructional technology’ are the outcome of
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technology of education, technology for education and technology in education. According to Council for Educational Technology, instructional technology helps to meet the challenges of new learning environment. Technology in the form of different media options, offers solutions to cope with all these challenges.

The meaning of the term ‘Multimedia’ is being dynamically redefined as technology evolves and progresses. Its meaning can be devised from the terms ‘multi’ (much or many) and ‘media/medium’ (means of communication). Hence, as the name implies, multimedia is the integration of multiple forms of media with the intent of communicating. Illustrated Oxford Dictionary (1998) interprets a medium as ‘the intervening substance through which impressions are conveyed to the senses’. A medium of instruction is any person, material or event that establishes conditions that enable the learner to acquire knowledge, skills and attitudes (Edling and Paulson, 1972). Media is the means for transmitting and delivering messages (Gerlach and Ely, 1980). In this sense, the teacher, the textbook and the school environment are the media.

Multimedia, is the combination of various media types such as text, images, audio and video, into an integrated multi-sensory interactive application or presentation to convey information to an audience. Traditional educational approaches have resulted in a mismatch between what is taught to the students and what the industry needs. As such, many institutions are moving towards problem-based learning as a solution to producing graduates who think critically and analytically and are creative, so as to solve problems. Multimedia technology can be used as an innovative teaching and learning strategy in a problem-based learning environment by giving students a multimedia project to train them in this skill set.

So Multimedia can be defined as a technique that supports the physical and logical co-existence and interactive use of heterogeneous media classes such as text, video, audio, animation, simulation and graphics and variety of activities. Vaughn (1993) has defined multimedia as a ‘woven combination of
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Multimedia in Classrooms

When we learn, it stimulates cells in the brain to grow branch like extensions called dendrites. Each dendrite is another neural pathway, by which cells can connect to each other. The ‘greater depth of meaning’ really refers to cells making more connections and finding new pathways to other cells, i.e. maximising the number of connections they make by providing multiple contexts for learning the same thing. The more ways we learn something - in a variety of contexts, using multiple intelligences, triggering emotions, through several types of media - the better the learning is. In future such breadth of experiences will allow more easy access to what has been learned. So the use of computers, graphic organizers and personal investigation should be encouraged for a multi-pronged approach to learning.

A multimedia learning environment involves a number of components or elements in order to enable learning to take place. Hardware and software are only part of the requirement. Multimedia learning integrates many types of media to provide flexibility in expressing the creativity of a student and in exchanging ideas. Multimedia when used in conjunction with traditional teaching methods can help create interest in individuals that may otherwise seem uninteresting in the course content. Multimedia when used properly can serve as a powerful tool to take learning to a higher level. Many teachers are unaware of how multimedia can be used to enhance the learning environment. Education will become ‘edutainment’ if multimedia is adequately harnessed.

Recognising the potential of multimedia in teaching and learning, most of the popular publishers came up with a lot of multimedia educational software. One of the main aims of establishing State Institutes of Educational Technology (SIET) in India is to plan, research, produce and evaluate educational multimedia software.

The introduction of multimedia into schools is seen by many as an important step in ‘technological revolution’. The term describes the impact of
multimedia; it refers to important changes in approaches to teaching and learning and not to simplify the particular means by which material is produced. Like many of the tools available in modern classrooms, multimedia technology can be seen as a neutral resource able to support a full range of teaching and learning styles.

Multimedia activities encourage students to work in groups, express their knowledge in multiple ways, solve problems, revise their own work, and construct knowledge. The advantages of integrating multimedia in the classroom are many. Through participation in multimedia activities, students can learn about the impact and influence of different media.

The implications of many studies for the educator are enormous. Almost everyone must be equipped to meet the technological demands for the future if they are able to work and prosper. Strategies such as those implemented by the National Grid for Learning (NGFL) and New Opportunities Fund (NOF) have ensured that there are policies for meeting targets for delivering internet access to schools and training teachers in the effective use of multimedia. All those working in schools have seen a tremendous change in the profile of multimedia. The comparison between the Traditional learning environment and the Multimedia learning environment is represented in Figures 2.8.
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Traditional Learning Environment:

![Teacher](Teacher) ➔ One way flow ➔ Students

Multimedia Learning Environment:

![Teacher](Teacher) ∩ Multimedia ∩ Student

Figure 2.8
Comparison between Traditional Learning Environment and Multimedia Learning Environment

Educational Potentials of Multimedia

Some potentials of multimedia that come into play when used for instructional purpose are stated below.

- The images used in multimedia offer a more direct accessible means of communication than printed texts. Images often help a student to learn a new concept or idea.

- Animations may help a concept to ‘come alive’ or gain meaning for a learner. The use of multimedia in science teaching and learning can extend access to process, concepts and experiments to learners in at least three ways: by letting them see processes which may be too fast, too slow or too dangerous to observe ‘live’, in real time; by helping to explain and illustrate some of the difficult concepts in science; and by allowing them to ‘do’ experiments that would otherwise be impossible.
Virtual tours allow students to explore spaces that they may never be able to get to (for example, human body) or to visit places that would otherwise be difficult.

Dissection of animals and human beings in Biology can be done without offending any ethical code.

The use of multimedia in teaching can extend access to other people, cultures and experiences in many ways especially in the CD-ROMs designed to promote foreign language skills.

Multimedia documents can be easily shared.

Expenditure related to real models and materials can be minimised.

Using different media motivate different sense organs and meaningful learning is promoted.

**Role of a Teacher in Multimedia Learning Environment**

Today’s teachers who make extensive use of co-operative learning and project-based work develop skills as intellectual ‘coaches’ and undertake a new role as the activity designer and facilitator rather than the chief ‘doer’ or centre of attraction. The teachers have to carry out several complex time-consuming tasks such as assessing proposed multimedia for relevance and content, to be able to facilitate learning using multimedia products. The areas to be assessed may include curriculum content, teacher use, student use, programme content, programme operation and publisher information. The teacher should gain confidence and competence in using the material, organise access to the technology, and arrange technical and software training to create multimedia products.

Multimedia offers the teacher many benefits including satisfying educational objectives, increasing students’ understanding, demonstrating events, showing places and conducting experiments that would otherwise be impossible. Sharing of multimedia outputs is to be done carefully such that it will not disturb other learners working in the same classroom. The teacher should determine the purpose or expected outcomes that he or she hopes to achieve by using multimedia. The flexibility of multimedia could be capitalized...
upon to offer the learner opportunities to modify and influence the nature of the learning process itself by providing problems, scenarios and simulations that allow the learner to progress along various levels of thought, manipulate the basic parameters of the situation and test out alternatives that might not otherwise be possible with traditional instructional methods.

The teacher can use multimedia to modify the contents of the material. It will help the teacher to represent in a more meaningful way, using different media elements. These media elements can be converted into digital form, modified and customized for the final presentation. Incorporating digital media elements into the project will enable students to learn better since they use multiple sensory modalities, which would motivate them to pay more attention to the information presented and retain the information better.

Educators need to explore how learners and its users interact with content and processes as well as other short and long term goals; intended and possible outcomes, the richness, depth and multimedia technology and the potential for mixed methodological evaluations utilizing the diverse range of interactions allowed by multimedia.

**Role of Multimedia in Teaching and Learning of Mathematics**

Mathematics involves a plenty of abstract concepts in Arithmetic, Two Dimensional Geometry, Calculus, Sets, etc. The branch like Solid Geometry of Mathematics involves many experiences which the students can only comprehend through visual experiences. So use of multimedia in Mathematics classrooms can equip teachers to help students to concretise abstract concepts.

Multimedia is a very powerful resource that can bring about substantial changes in teaching and learning school subjects, especially Mathematics. Parents, students and teachers can rightfully expect that teaching of all subjects in the curriculum should make the best possible use of multimedia resources, and that means the selection and development of multimedia resources must be made to fit the needs of the subject, and not the reverse.
Developing Multimedia Instructional Packages

Creating multimedia packages is both challenging and exciting. Fortunately, there are many multimedia technologies that are available for developers to create these innovative and interactive multimedia applications (Vaughan, 1998). These technologies include Adobe Photoshop and Premier to create and edit graphics and video files respectively.

PowerPoint, Podium, Macromedia Action and Authorware Star, and Hyper Studio, 3D Maths, and Flash Player are examples of application software packages commonly used to easily create multimedia presentations. Popular multimedia authoring software which allow teachers to easily create their own multimedia tutorials and students to create multimedia reports for class projects are Macromedia Director K-12, Authorware Star, Authorware Professional, Asymetrix Tool book, Apple HyperCard, Hyper Studio, Super Card, Tool Book, Quest, Icon Author, and The Multimedia Workshop. Free trial versions of these softwares are available on the Web.

Any instructional package designed and developed integrating multimedia technology is termed as Multimedia Instructional Package. Any of the Models of instructional packages can be applied to develop a Multimedia Instructional Package.

2.3 Perspectives on Solid Geometry

The word ‘geometry’ comes from two ancient Greek words, ‘Geo’-meaning ‘earth’ and ‘metry’-meaning ‘to measure’. These Greek words, as well as the word ‘geometry’, may themselves be derived from the Sanskrit word ‘Jyamiti’ (in Sanskrit, ‘Jya’ means an arc or curve and ‘Miti’ means correct perception or measurement). The origins of Geometry are very ancient (it is probably the oldest branch of Mathematics) with several ancient cultures (including Indian, Babylonian, Egyptian, Chinese, as well as Greek) developing a form of Geometry suited to the relationships among lengths, areas, and volumes of physical objects. In these ancient times, Geometry was used in the measure of land (or, for today, surveying) and in the construction of religious and cultural artefacts.
A useful contemporary definition of Geometry is that which is attributed to the highly respected British mathematician, Sir Christopher Zeeman (as cited in Watson, Jones, and Pratt, 2013): “Geometry comprises those branches of Mathematics that exploit visual intuition (the most dominant of our senses) to remember theorems, understand proof, inspire conjecture, perceive reality, and give global insight” According to Royal Society/Joint Mathematical Council (JMC, 2001), as cited in Hopkins, Pope, and Pepperell (2009), “there are transferable skills that are needed for (but not taught by) all other branches of Mathematics (and Science)”. The Royal Society/JMC report suggests that the aims of teaching Geometry can be summarised as follows.

- to develop spatial awareness, geometrical intuition and the ability to visualise;
- to provide a breadth of geometrical experiences in 2 and 3 dimensions;
- to develop knowledge and understanding of and the ability to use geometrical properties and theorems;
- to encourage the development and use of conjecture, deductive reasoning and proof;
- to develop skills of applying Geometry through modelling and problem solving in real world contexts;
- to develop useful ICT skills in specific geometrical contexts;
- to engender a positive attitude towards Mathematics; and
- to develop an awareness of the historical and cultural heritage of Geometry in society, and of the contemporary applications of Geometry.

The above definitions of and a consideration of the aims of teaching Geometry, leads one to think why it should be included in the school Mathematics curriculum.

As per the findings of Dutch researchers Pierre and Dina van Hiele, (as cited in Clements and Battista, 1992), who examined the question of why so many people have difficulty in learning Geometry, people develop their knowledge and understanding of geometric concepts in a predictable sequence of levels of development. At the earliest level in the van Hiele scheme, known as the Pre-Recognition Stage, students perceive geometric shapes but they are
generally unable to identify them. They can recognise broad categories of shapes, such as straight-sided shapes as compared to curved-sided shapes. But they are unable to construct mental images of shapes or hold shapes in their minds for any length of time. At the next higher level in the scheme, students do hold mental images of shapes. However, these images are not based on an analysis of the number of sides and/or angles the shape possesses. Rather, the mental images represent a common appearance of a shape. For example, ‘any shape that has a horizontal base and sides merges to a point’ would be likely to fit the mental image of a ‘triangle’. Without regard to the number of sides, a child at this level would identify such a shape as a triangle. A three-sided shape in a different orientation would have a different name, such as, perhaps, an ice-cream cone. The child at this level evaluates a shape to see if it fits her mental model for shapes of that kind. This level is the **Visual level**. Beyond the Visual level, students develop the ability to analyse shapes in terms of their properties. They examine the number of sides and/or angles in order to determine what a shape would be called. At this level, a child might examine a three-sided shape that is in an unusual orientation and declare that it is a triangle, ‘because it has three sides’. This level, known as the **Descriptive/Analytic level**, is common among students in elementary school. Students who have progressed beyond the Descriptive/Analytic level are able to reason with definitions of shapes and they are able to make sense of relationships within and among different shapes. Students at this level are said to be at the **Abstract/Relational level** because the relationships between shapes and between parts of shapes are abstractions. Students at this level understand categories of shapes and how a shape can belong to more than one category at a time. Beyond this, students develop the ability to use logic and reasoning with regard to geometric relationships.

The study of Geometry contributes to help students develop the skills of visualisation, critical thinking, intuition, perspective, problem-solving, conjecturing, deductive reasoning, logical argument and proof. Geometric representations can be used to help students make sense of other areas of Mathematics: fractions and multiplication in arithmetic, the relationships
between the graphs of functions (of both two and three variables), and graphical representations of data in statistics. Spatial reasoning is important in many curriculum areas like science, geography, art, design and technology and especially in Mathematics. Working with practical equipment can also help develop fine motor skills. Geometry provides a culturally and historically rich context within which to do Mathematics. There are many interesting, sometimes surprising or counter-intuitive results in Geometry that can stimulate students to want to know more and to understand why. Geometry that is presented in a way that stimulates curiosity and encourages exploration enhances students’ learning and their attitudes towards Mathematics. Encouraging students to discuss problems in Geometry, to articulate ideas and to develop clearly structured arguments to support their intuitions can lead to enhanced communication skills and recognition of the importance of proof. The contribution of Mathematics to students’ spiritual, moral, social and cultural development can be effectively realised through Geometry. Geometry offers a rich way of developing visualisation skills. Visualisation allows students to explore Mathematical and other problems.

Geometry is a core subject in Mathematics. According to extensive evaluations of Mathematics learning such as the National Assessment of Educational Progress (NAEP), there has been a difficulty among students to learn basic geometric concepts as well as to achieve skills in geometric problem solving. This poor performance is due in part to the current elementary school Geometry curriculum. Instead, Geometry should be the study of objects, motions and relationships in a spatial environment. Geometry instruction should develop geometric ideas, spatial visualization and geometric problem solving ability.

Geometry is the subject that studies about shapes and figures. There are two types of shapes around us - geometric shapes and non-geometric shapes. Geometric shapes are the shapes that have predefined properties explained for that particular type of shape. Whereas, a non-geometric shape is not predefined and does not have common properties. The classification of geometric shapes
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on the basis of dimensions is as follows: (1) Zero dimensional shape - a point, (2) One dimensional shape – a line having a length as its dimension, (3) Two dimensional shapes - having length and breadth as two dimensions, for example, square, triangle, rectangle, parallelogram, trapezoid, rhombus, quadrilateral, polygon, circle, etc., (4) Three dimensional shapes - with length, breadth and width (height) as three dimensions, for example, cube, cuboid, cone, cylinder, sphere, pyramid, prism, etc., and (5) Higher dimensional shapes – a few shapes expressed in dimensions higher than three, which are not usually prescribed for study at Secondary School Level.

Solid is one of the major states of matter. It is characterized by structural rigidity and has definite volume. In Geometry, the structure that is in three (even higher) dimensions, are known as Solids or Geometric Solids. The study of the Mathematical properties, volume and surface area of solid objects is called as Solid Geometry.

Conceptual Clarity in Solid Geometry

A concept is defined as a class of stimuli or a coding system. According to Newell and Gagne (1970), a concept is a set of learned stimuli that belong to the same category or classification, but which can be done without applying such rule as ‘a chair must have four legs and a seat and a back’. Recognition of the chair would be immediate upon presentation of an example just as rejection of a stool would be immediate and not subject to any logical application of a rule. According to Hunt, Marín and Stone (1966), ‘A concept is a decision rule which, when applied to the description of an object specifies whether or not a name can be applied’.

Concept formation is a process of developing concept, as conceived by Piaget, Bruner, and Vygotsky. Concept-centered teaching helps in meaningful learning. It is a process of sequential instruction that applies many kinds of strategies for students’ understanding. These sequences of learning are: definition, example, example with reason, non-example with reason, comparison and contradiction. Conceptual Clarity, i.e. clearness in the understanding of the characteristics and the logical linkage within a concept
can be ensured in students if every teacher follows the process of concept development.

**Concepts related to Geometry** are also recognized as appropriate learning contents for young children. It should be pointed out that the formal Geometry known to most adults is not what is being suggested. The unique cognitive abilities of young children do not equip them for dealing with logical proofs. However, young children can learn about geometric concepts on a concrete level. Understandings related to Geometry include the ability to identify geometric figures and solids. Many children recognize and sort out shapes, circles, squares and triangles at an early age itself and they also learn the names easily.

Geometric Solids are distinguishable on the basis of the characteristics of their surfaces. Surfaces of Solids are either flat or curved. Some Solids have only flat surfaces (cubes, pyramids, rectangular prisms). Others have both flat and curved surfaces (cones & cylinders), whereas a sphere has only one curved surface. Geometric competencies for young children also include the ability to construct geometric figures and Solids. Teaching concepts in Solid Geometry is not an easy task. It deals with scientific objectives. Achieving scientific objectives can be possible only by learning a concept. The general mental notion of things or events is arrived at by the processes of perception, classification and discrimination; it is used as a basis for thought and is expressed through symbolic languages. A concept can be thought of as lower or higher order or as from the easily imagined to the highly abstract.

**Conceptual Clarity in Solid Geometry** is defined as observation of Solid figures and identification of their characteristics, awareness about solid figures and shapes, ability to adapt with different positions of Solid figures and expression from characteristics of solid figures. Many studies have proved that the root cause for the lack of Problem Solving Ability, the main objective of Mathematics instruction, is due to the inability of students to comprehend certain concepts/images related to geometric figures. So conceptual Clarity in
Solid Geometry is very important especially when this branch of Mathematics is introduced at the Secondary School level.

**Problem Solving Ability in Solid Geometry**

**Problem solving** is the framework of pattern within which creative thinking and reasoning takes place. It is the ability to think and reason on given levels of complexity. People who have learned effective problem solving techniques are able to solve problems of high-level complexity than more intelligent people who do not have such training. When an individual faces a problem, a state of tension is created in the mind. Some individuals are able to solve problems sooner than others. This indicates that there are different levels of Problem Solving Ability, ranging from average to the highest ability, depending upon the difficulty level of the problem and the ability level of the problem solvers. Individuals having average problem-solving ability can solve simple problems while those having high level ability can solve complex problems. Problem solving is a complex mental process involving visualisation, imagination, manipulation, abstraction and the association of ideas. Problem solving requires unique and original responses; the best problem solvers are non-conforming and creative people.

Problem Solving has special importance in the study of Mathematics. A primary goal of Mathematics teaching and learning is to develop the ability to solve a wide variety of complex problems. Today education has undergone multifaceted change. Changing Mathematics Education will require restructuring the culture of the Mathematics classroom and the epistemological perspective of Mathematics teachers. A widely held belief is that the coverage of content and accumulation of mathematical facts are more important than teaching students to think and solve problems. The fundamental goal of all instruction is to develop skills, knowledge, and abilities that transfer to tasks not explicitly covered in the curriculum. It has been established that the problem-solving skills occupy a very important place in Mathematics teaching. The National Council of Teachers of Mathematics (NCTM, 1989) recommended that problem solving should be the focus of School
Mathematics. In other words, the art of problem solving is the heart of Mathematics teaching. Therefore, it becomes necessary for the Mathematics teacher to constantly and consciously follow methods that would maximise the inculcation of problem-solving skills among the students.

According to Mckeachie and Doyze (1966), the elements involved in problem solving are the weighing of goals, the discovery of appropriate means to goals and the assessment of the probability that a given course of action will lead to the chosen goals. According to Ekstrand (1976), Stemberg and Bourne (1991), the stages of problem solving are preparation, production and judgement. Rebok (1987) has named three steps of problem solving as:

- Preparation - one needs to understand what the problem is and prepare oneself to solve the problem.
- Production - generate possible solutions.
- Evaluation - to decide how good the solution is.

Feldman (1989), has also identified three major steps involved in Problem Solving Ability, viz.

- Preparation of the creation of solutions.
- Production of solutions.
- Judgement and evaluation of solutions that have been generated.

Besides, several problem solving strategies are developed by many educationists. Random Search strategy by Rebok (1987), Algorithm strategy by Berk (1996), Heuristic strategy by Anderson (1985), and Trial and Error strategy by Baron (1996) are the major among them. Also, there are several theories of Problem solving. Well known among them are Gestalt theory by Dunckner (1945), Information Processing theory by Newell and Simon (1972) and Learning theory or Associationist approach by Thorndike (1911), Watson (1919) and Pavlov (1927).

Problem Solving Ability in Mathematics can be broken into two major component processes, viz. Problem Comprehension and Problem Solution. Learning Mathematics consists of acquiring a large number of schemas. The students bring this personal schema to solve mathematical problems. Personal
schema is built in accordance with one’s cognitive structure. Cognitive learning strategies recommend that the school curriculum in most subject areas be organized around real life problems that learners work on for days or weeks. Usually, we now have curricula isolated by disciplines (Algebra, Biology, Geometry, etc.) that identify lists of topics, facts and skills to be covered by the end of an academic session. Such curricula typically place learners in a relatively passive role and encourage rote or non-meaningful learning.

But, Problem Solving Ability in Solid Geometry requires visualization of third dimensional images and creating that in the minds of the students is the duty of every Mathematics teacher.

**Achievement in Solid Geometry**

In educational system, focus is laid upon student’s performance and achievements. Learning outcomes, behavioural change and mental development of students are the main objectives to be measured. The amount of attainment of these objectives is referred by the term ‘Achievement’. This can be measured through a test, ‘Achievement Test’, prepared on the basis of some pre-determined educational objectives. According to Good (1973), ‘Achievement refers to the standard performance of students in the group under consideration for a test developed to measure curricular outcomes’. Achievement is the knowledge attained or skills developed and it is represented in the form of test scores.

During teaching-learning process, different objectives based on different domains of learning are dealt The McCormack and Yager (1989) Taxonomy of teaching and learning Science incorporated five categories or domains of Science Education. The Taxonomy was designed to help students become scientifically and technologically literate. The five hierarchical domains were organized by importance as follows.

(a) Knowing and understanding (scientific information)
(b) Exploring and discovering (scientific processes)
(c) Imagining and creating (creative)
(d) Feeling and valuing (attitudinal)
(e) Using and applying (application and connections)
The Taxonomy listed what students could do or learn in each domain. McCormack and Yager (1989) contended that Science Education limited students to the first two domains that primarily focused on the processes and products of Science. They stated that the other three domains needed to be included more often in Science instruction due to the increased focus on science, technology, and societal issues.

Usually, for Science subjects and Mathematics, teachers conduct achievement tests by including the first two and the last domains suggested by McCormack and Yager. So Achievement in Solid Geometry is the amount of attainment by the students on the objectives of teaching Solid Geometry measured through a test prepared in which the test items were prepared on Knowledge, Process and Application Domains.

Conclusion

The Investigator examined the theoretical frameworks of Instructional Packages, Multimedia Packages and Learning of Solid Geometry. This helped the investigator to mould the study and to adopt a suitable procedure for the conduct of the study.