Developing Instructional Models

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Learning theories collectively emphasize fundamental aspects of the learning process, including the capacity to acquire knowledge, the role of practice and reinforcement, the influence of motivation, the importance of understanding and insight, as well as the dynamics of transfer, retention, and forgetting (Hilgard, 1986, as cited in Khin Zaw, 2001). Research consistently shows that learners engage more effectively with meaningful materials and tasks than with abstract or nonsensical content, underscoring the value of relevance and comprehension in fostering deeper learning. Furthermore, McConnell (1942, as cited in Khin Zaw, 2001) highlights that successful learning depends on the learner's ability to discriminate differences and to generalize across similarities, skills that are central to building adaptive knowledge and applying it across diverse contexts.

Constructivist theories emphasize the development of critical thinking and the understanding of broad concepts rather than the simple mastery of factual information. They propose that students who cultivate a deep grasp of essential principles through their own reasoning are better prepared for the complexities of a technological world. Constructivist learning is inherently active; it requires the interaction of ideas and processes, where new knowledge is built upon prior knowledge. Learning becomes more meaningful when situated in contexts that are familiar and relevant to students. As Collins (2002, cited in Biggers, 2013) notes, learning is further enriched when students engage in discussions that explore these ideas and processes.

Constructivism highlights hands-on, activity-based teaching and learning, enabling students to build their own frameworks of thought. It underscores the personalized ways learners internalize, shape, and transform information, leading to the construction of new understandings through evolving cognitive structures. In this approach, the teacher creates situations that stimulate independent thinking rather than guiding students to predetermined answers, allowing them to form their own ideas and pathways. Within constructivist classrooms, learners are active participants, subject matter is rooted in authentic, real-life contexts, and thinking is encouraged to be open-ended and divergent.

The Application of Instructional Modelling

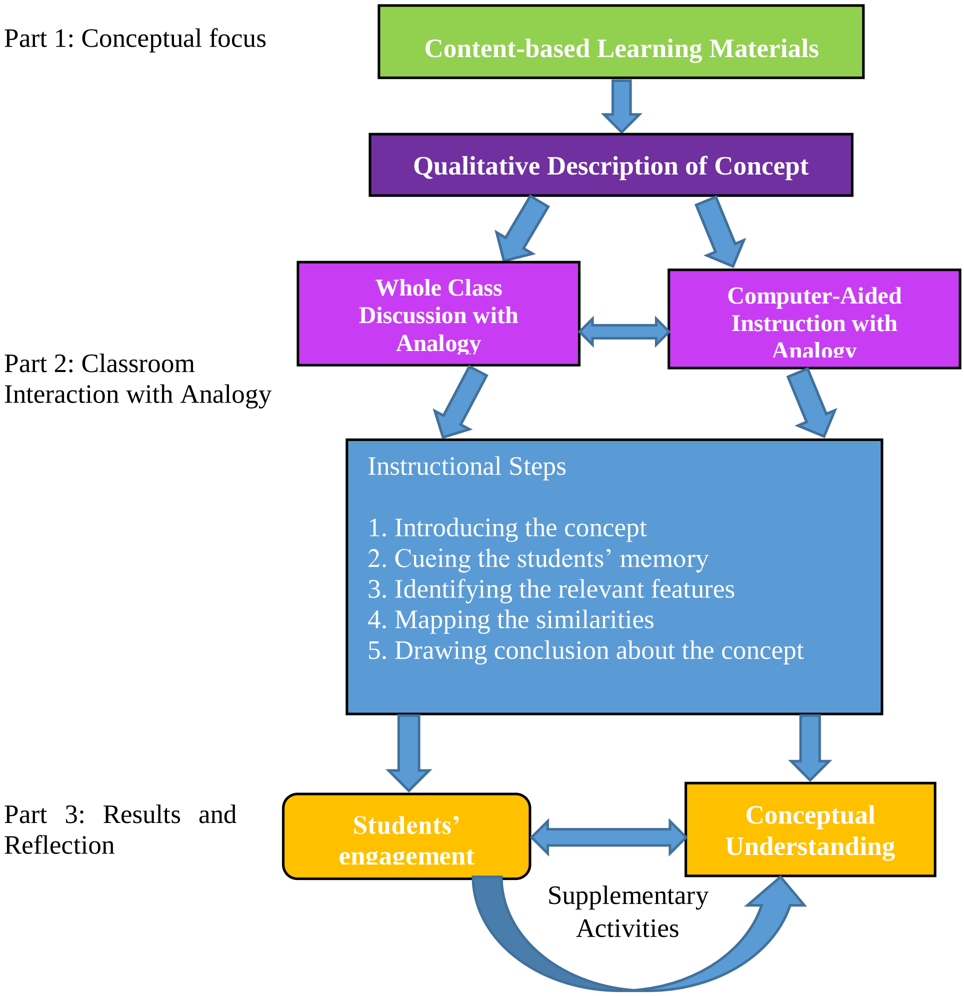
The Integrated Interactive Conceptual Instruction Model by Khwanda et al. (n.d.) was adapted to develop the Interactive Conceptual Instruction Model. In this adaptation, research-based learning materials in Part One, which emphasizes conceptual focus, are replaced with content-based materials. In Part Two, classroom interaction is integrated with analogy through the Teaching with Analogy (TWA) Model proposed by Alice (2011). Although the TWA model originally consists of six steps, only five were applied to strengthen students' conceptual understanding of physics at the basic education high school level. Finally, results and reflection are incorporated to emphasize student engagement and conceptual growth, with supplementary activities provided to further support interactive conceptual instruction.

Learning is the process of acquiring new information, while memory refers to the persistence of that learning in a form that can be accessed at a later time (Squire, 1987, cited in Gazzaniga et al., 2002). Both learning and memory are commonly described in three stages: encoding, storage, and retrieval. Encoding involves processing incoming information for storage and occurs in two steps: acquisition and consolidation. Acquisition registers inputs through sensory buffers and analysis, while consolidation strengthens these representations over time. Storage, the outcome of acquisition and consolidation, establishes and maintains a lasting record. Retrieval then draws on stored information to generate conscious representations or to guide learned behaviors, such as motor actions (Gazzaniga et al., 2002).

Transfer of learning between tasks is strengthened when teachers guide learners to focus on the specific skill being developed and encourage reflection on its potential applications. In this way, pupils enhance their thinking processes. The activities are intentionally designed to create cognitive conflict a state of dissonance that arises when learners encounter an event they cannot explain using their existing conceptual framework or methods of processing information (Adey, 1992:138, cited in Bartlett & Burton, 2012). The proposed model draws upon and integrates elements from Glaser's Basic Teaching Model, Talyzina's Psychological Cybernetic Model, Stolurow and Davis's Computer-Based Model, Flanders's Interaction Analysis Model, Dr. Khin Zaw's Multimodal Model, Gredler's Selection of Instructional Events, and established theories of memory. Grounded in these foundations, the new instructional design was constructed with three components, as illustrated in Figure 1.

Figure 1

Teaching model for interactive conceptual instruction



In Part One, the conceptual focus is introduced and discussed with the students. To enhance clarity, different colors are used in the content-based learning materials, allowing students to easily distinguish the prescribed materials outlined in the basic education curriculum.

This section aims to develop conceptual understanding through the use of content-based learning materials as the central link. At the high school level, these materials are prescribed to strengthen students' comprehension of physics. The Grade Ten curriculum encompasses the entire upper secondary physics course, systematically organized into six major fields: (1) Mechanics, (2) Heat, (3) Waves and Sound, (4) Optics, (5) Electricity and Magnetism, and (6) Modern Physics. The sequence of topics was deliberately chosen, as each is considered essential for building the foundation of subsequent concepts. For instance, Mechanics must be studied first, as it underpins the understanding of other areas. Thus, the contents of Grade Ten overlap and are interconnected. This part also involves assessing students' prior knowledge through content-based learning materials, concept tests, questions, and demonstrations, all of which are designed to spark classroom discussion and promote learning through cognitive conflict strategies.

In Part Two, classroom interaction through analogy is emphasized as a core strategy for interactive conceptual instruction. To aid clarity, violet is used for qualitative descriptions of concepts, while lilac is used for other terms, allowing students to distinguish physics concepts from the instructional steps designed to teach them. This stage fosters classroom engagement through both whole-class discussions with analogy and computer-aided instruction with analogy. Since student interaction is central to constructivist theory, learners' prior knowledge is carefully considered. At this stage, each concept is explored through both discussion and technology-based analogy, enabling students to develop a deeper qualitative understanding. A reversible arrow illustrates the relationship between whole-class discussion and computer-aided instruction, indicating that either approach may be used to achieve the qualitative description of the concept.

Some lessons, such as Mechanics, Heat, Waves and Sound, and Optics, are well suited for whole-class discussion. Within these areas, topics like Pascal's Law, transfer of heat, resonance column and organ pipe, refraction of light and the laws of refraction, refractive index, and image formation by lenses are taught through whole-class discussion with analogy. In contrast, topics in Electricity and Magnetism and Modern Physics are more effectively addressed through computer-aided instruction. These include electric lines of force, lightning conductors, electric potential of the earth, capacitance, current and electric circuits, electronic logic gates, and X-rays, which in this research are taught using computer-aided instruction with analogy. When necessary, teachers may combine both methods to enhance students' understanding, depending on the available time and the school context, while also maintaining student engagement. This stage focuses on the qualitative description of concepts, with teaching through analogy serving as a means to help students draw informed conclusions.

Five steps of analogy are employed to develop a qualitative understanding of concepts. These steps include:

(i) Introducing the concept. This step serves as a brief introduction leading to a full explanation, depending on how the analogy is applied. If the analogy functions as an advance organizer, the concept is introduced at this stage. Alternatively, if the analogy is intended for review, the concept is fully taught before the analogy is applied.

(ii) Cueing the students' memory. This step introduces the analogy and gauges students' familiarity with it through questioning or discussion. If students demonstrate limited understanding, the analogy is either adjusted or discontinued. The teacher must ensure that at least one clear similarity between the analogy and the target concept is recognized by the students.

(iii) Identifying the relevant features. This step focuses on explaining the analogy at a level appropriate to students' understanding. The teacher clearly identifies the relevant features of the analogy that will be used as the basis for developing the target concept in the next stage.

(iv) Mapping the similarities. In this step, the features of the analogy are explicitly linked to the target concept(s). The conceptual mapping may converge on a single concept or extend to develop two or more related concepts.

(v) Drawing conclusions about the concept. After mapping the similarities, a summary of the target concept should be presented to consolidate student learning. To reinforce understanding, the teacher asks guiding questions related to the lesson, provides feedback, and addresses any misconceptions. Each stage of the process overlaps and connects with the others, ensuring coherence in learning. For instance, the qualitative description of concepts in Mechanics, Heat, Waves and Sound, Optics, Electricity and Magnetism, and Modern Physics can all be effectively discussed and presented through this model.

In Part Three, the stage of results and reflection highlights student engagement and demonstrates conceptual understanding. This stage centers on assessment and feedback, with questions and concept tests prepared to verify students' grasp of the lessons. The reversible arrow signifies outcomes derived not only from active participation but also from demonstrated conceptual understanding. When needed, supplementary activities are provided to address misconceptions and support students who encounter conceptual difficulties.

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