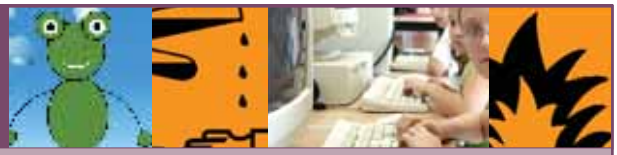
Toxicology in the Classroom

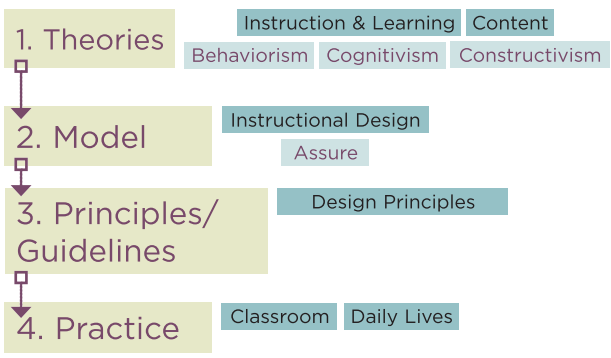


by Maizurah Omar and Rahmat Awang

Although nonchemical methods exist to control pests, pesticides are essential for farming economies of today, especially in developing countries and countries with economies in transition. However, infants and children are particularly vulnerable to pesticides and other toxic chemicals because their bodies are smaller and still developing. Children also face greater exposure than adults due to their hand-to-mouth behaviors. And children living in farming areas or whose parents work in agriculture suffer greater pesticide exposure than other children.

A recently completed IUPAC project was designed to raise awareness among young children about the potential adverse effects of chemicals and, in the process, help reduce the careless use of pesticides. Carefully developed over the past four years, "Toxicology in the classroom" (Toxiclaro for short) is a multimedia resource that will help teachers educate their students about pesticides and health. Toxiclaro is a virtual toolbox, offering training materials, a curriculum, and resources such as games, experiments, and a virtual house to explore—all of which provide for a basic understanding of toxicology and awareness of the need for protective and precautionary measures.

The Toxiclaro initiative originated from the IUPAC Chemistry and Human Health Division and the IUPAC Committee on Chemistry Education (CCE), which formally met to plan the project in May 2005 at the Federal Agency for Risk Assessment, Berlin, Germany. The project is managed by a task group of professionals from the World Health Organization (WHO), IUPAC, and the National Poison Centre of Malaysia.



Flow Chart for the Theoretical Framework and Instructional Approach of the Toxiclaro project.

The project also is an expansion of a project of the International Programme on Chemical Safety of the World Health Organization. The IPCS multilevel course aims at training different groups of people in the sound management of pesticides. The course material addresses trainers and technical and medical personnel. The Toxiclaro project aims to expand this approach to young people, educating them about protecting themselves from the harmful effects of pesticides and hazardous chemicals, and developing a safety culture for the future.

Development of the Courseware

This article describes the underlying theory that guided the entire web-based courseware development project. The following discussion explains briefly the terms "technology" and "instruction" in the context of teaching and learning through multimedia, to enable the reader to appreciate three important learning theories that grounded the project's development. From the theories emerged a model that we used to systematically help us develop the courseware prototype. We also employed some crucial design principles and guidelines to further help us with the details in building the courseware.

Theoretical Framework and Instructional Approaches

The Toxiclaro prototype is based on a top-down research model that encompasses theories, and principles about the best instructional approach for this type of multimedia material.

In the context of this project, the term "technology" refers to both product and process. The term "instruction" refers to a systematic process of arranging information and the environment to facilitate learning. The environment, in this case, refers not only to where instruction takes place but also to the method, media, and equipment needed to convey information and guide the learner. Learning is defined as the development of new knowledge, skills, or attitudes as an individual interacts with the information and the environment.[1]

Following are some of the questions the instructional media designer had to answer before embarking on the development of the courseware:

- What knowledge and skills are meant to be imparted by this multimedia courseware? How

can the instructional media designer be sure that the information delivered has been received by the learner as intended?
- How much information has actually been understood by the learner and how much of this information did the instructional media designer and content developer want the learner to understand?
- How do children ages 7–13 learn?
- What are the appropriate materials?
- Can animation, text, and audio increase the potential for children to learn and remember new information as well as to apply it in their daily routines?

The learning theories of behaviorism, cognitivism, and constructivism were instrumental in designing the courseware.

Behaviorism

According to this theory, objectives or intentions should be clearly stated and the focus should be on delivering the facts. In this context, the learner is simply a recipient of instruction. Behaviorist theory refuses to speculate on what goes on in a learner's brain when learning takes place; therefore, the assessment of outcomes relies solely on observable results, such as correct and incorrect answers on questionnaires/exercises. As a result, behaviorism has limited utility for designing instruction for higher-level skills such as evaluations or problem solving. For this reason, the designer drew upon a few elements of behaviorism, but drew more heavily upon the theory of cognitivism.

The following elements of behaviorism are integrated into the courseware:
- clear-stated objectives for each lesson
- exercises such as quizzes with multiple choice and open-ended questions
- evaluation of recalling facts (e.g., naming of pesticides, risks of pesticides)
- reward achievement and motivate learning (i.e. , using reinforcement words such as "Well done!")
- remedial exercises to reduce failure in learning

Cognitivism

The theory of cognitivism explains how information is received, processed, and manipulated by the learner. According to the theory, new information is initially stored in short-term memory, but only if the information is "rehearsed" will it be stored in long-term memory. Because short-term memory is limited, only a small amount of information can be attended to at any given time. In scientific terms, the capacity of short-term memory is limited to 7+ - 0 chunk of information. An effective way to maximize the storage available in short-term memory is to present it in a variety of forms (i.e., multimedia), such as images, spoken and written text, video, and animation. "Rehearse," "practice," and "repeat" are important elements to ensuring new information is moved to long-term memory.

Yet, our brain is also greatly influenced by our perception, which determines how we interpret what we see. The brain automatically selects and organizes sensory information (dominated by the visuals) to fit with desired outcomes. Perception is therefore a great challenge to any instructional media designer. Media designed to deliver knowledge and skills should be able to first attract the viewer's attention and then to sustain it throughout the process.

Piaget described three major components of mental development: schemata, assimilation, and accommodation.[1] Schemata are mental structures individuals use to organize their perceived environment. These schemata are adapted or changed during mental development and learning. They are used to identify, process, and store incoming information. As a result, individuals learn to classify objects according to their significant characteristics. These cognitive structures change by the process of assimilation and accommodation. Assimilation is the cognitive process whereby the learner integrates new experiences into existing schemata, constantly elaborating them. When new experiences do not fit, a modifying process or accommodation takes place resulting in the development of new schemata and existing schemata are extended.

Cognitivism acknowledges the uniqueness of individual children, who have their own schemata, their own environment. Therefore, instructional media must engage children's existing schemata, so that new information can be stored in long-term memory. Information should be broken into subtopics and should be presented in logical sequences, with many examples, and employing sounds, images and text. Children need choices that resonate with their own learning styles, including the ability to repeat material or reply to it.

Following are elements of cognitivism integrated in the courseware:

- forward and backward buttons to allow "Rehearse," "practice," and "repeat"
- multimedia, such as sounds, spoken words, text, pictures, and animations
- attractive layout design, stories, and interactive games to grab attention and motivate
- information broken into parts and logical sequence
- evaluation on higher cognitive skills such as categorization, classification, synthesis, analysis, abstraction, and judgment (e.g., cause and effect of different kinds of pesticides)

Constructivism

Constructivism focuses on the learner's prior knowledge and cognitive development. Using this approach, the learning environment is made as rich as possible to enhance students' ability to construct or assemble knowledge and resolve difficulties in solving problems. Heinich et. al make a clear distinction between the role of instruction in behaviorism and constructivism. According to them, instruction should not merely dispense facts but should provide ways to assemble knowledge. Many of the things we learn in childhood end up as inert knowledge that cannot be used despite being stored in long-term memory. We may have failed to make sense of new information, or the knowledge may be no longer useful. Knowledge is always dynamic, changing or becoming obsolete over time. Constructivism is very much concerned with this and emphasizes the importance of using existing knowledge to gain and apply new knowledge.

The focus of the designers of the Toxiclaro material is to build learning environments that take into consideration the specific needs of individual students and actively engage them in constructing new knowledge and meaningful experience. Most of the new information presented in the courseware is linked to, or in the form of, situated learning experiences, such as the daily activities encountered in children's own homes and surroundings.

The following elements of constructivism are integrated in the courseware:

- choices in learning such as stories, games, experiments, and lectures
- real-life stories about pesticides and chemicals for meaningful learning
- use of local environments to introduce new knowledge
- use of the scaffolding technique such as teacher's notes and teacher's guide to facilitate teaching and learning
- encouragement of elaboration thinking such as in story telling, experiments, and variety of examples
- evaluation of higher cognitive skills such as the ability to solve problems, make predictions, and critical judgment

Process Technology: "ASSURE" Model

There are more than 40 models commonly used in instructional design. The most simple and common is the ASSURE model, which was used for the Toxiclaro project. The acronym stands for:

A—Analyze Learner
S—State Objective
S—Select Method, Media, and Materials
U—Utilize Media and Materials
R—Require Learner Participation
E—Evaluate and Revise

Analyze Learner

The first step taken by the instructional media designer was to understand the character profile of our target audience. Most of the data gathered were from teachers and books related to the way children in specific age groups learn and behave.

State Objective

Each topic was broken into clear objectives that can be observed and measured. Some of the objectives were written in terms of degrees of achievement, such as asking users to provide at least three examples of pesticides.

Select Method, Media, and Materials

This task is extremely challenging and time consuming. On-going discussions, feedback, and formative assessments are activities that are regularly performed

by the instructional designers, teachers, multimedia developers, and content experts. Up-to-date, real-life case studies, tested laboratory experiments, references, pedagogical and layout design were important issues for the development team. The team also worked with young children to help develop story telling and games as well ideas to enrich instruction.

The instructional media designer used these design principles to help guide the work:

- legibility
- easy interpretration
- interactivity

Utilize Media and Materials.

The courseware was previewed and pretested by individuals and small and large groups at schools and conferences. In all the sessions, feedback received was used to edit and enhance the courseware.

Require Learner Participation

Most of the instruction used in the courseware invites and encourages learner participation through games, experiments, and quizzes, and through the variety of examples given for each topic.

Evaluate and Revise

The courseware designers used formative as well as summative evaluations. Most of the formative evaluations were carried out during the process of development. These included presentations to, discussions with, and feedback from content experts, instructional design experts (i.e., teachers), multimedia and graphic designers, and children. Formative evaluations consisted of children's assessments in the form of quizzes. Summative evaluations of learners' achievement have also been developed that can be used by teachers at the end of each topic.

Background

A workshop to review a draft version of the Toxiclaro package was held 15 August 2008 immediately following the WHO/EURO meeting on "Sound Management of Pesticides—Risk Reduction," Bonn, Germany. This was attended by Rahmat Awang, Nida Besbelli, Birger Heinzow, and Wayne Temple. Several amendments were suggested at this meeting that were incorporated by Awang and his informatics team in Malaysia. Awang had demonstrated the software to delegates at the WHO meeting prior to the workshop.

Awang subsequently delivered a PowerPoint presentation entitled "The Design and Development of a Multimedia 'Toxicology in the Classroom' Courseware for Young Children" at the 7th Annual Congress of the Asia Pacific Association of Medical Toxicology, 8–10 December 2008 in Chandigarh, India.

Next Steps

The project team will test run the courseware in three countries to further enhance its quality. This will involve organizing a series of train-the-trainer workshop for instructors and teachers on how to use the courseware. In this regard, the designers are planning to produce a training guide. Another component of the project will involve classroom monitoring, supervision, and reporting to ensure the courseware is properly implemented, to evaluate its effectiveness, and make improvements if needed.

An amended version of the Toxiclaro multimedia package can be found at <www.prn2.usm.my/toxicology2009>. Group members are currently reviewing this material and hope to finalize the project by the end of 2009.

Team Members

IUPAC Project Members: Wayne A. Temple, chair; Rahmat Awang; Nida Besbelli; John H. Duffus; Birger Heinzow; Irma Makalinao; Maizurah Omah; Lutz Rexilius; and Fritz Schweinsberg.

Pedagogical Experts: Maizurah Omar (instructional design and technology), Maznah Omar (science specialist for classroom teaching), Maizuyah Omar (chemistry specialist classroom teaching), Nurulain Ramli (chemistry teach teacher), and Bedariah Abdullah (biology teacher).

Multimedia Designers: Maizurah Omar (visual literacy), Nooreha Md. Salehen (graphic and animation), Muhammad Haifizullah Mohammad (multimedia), and Latifah Zaidi (graphic).

References

1. Heinich, R., Molenda, M., Russel, J., Smaldino, S.E.(1999). *Instructional Media and Technologies for Learning* (6th edition). London, Sydney, Toronto, Mexico, New Delhi, Tokyo: Prentice Hall.
2. Gardner, H (1983). *Frames of Mind: The Theory of Multiple Intelligences.* New York, Basic Books.
3. Omar, Maizurah (2000). *Teachers' Skills in Using Visual Materials.* PhD Thesis. Bath, UK.

www.iupac.org/web/ins/2004-045-1-700