3 Linking Learning Objectives, Pedagogies, and Technologies

Chapter Outline

- Linking instructional strategies to learning objectives
- Types of technology for educational uses
- Principles for the selection of technology for educational uses.

By the End of This Chapter, You Should Be Able To

- Differentiate types of learning objectives;
- Select an appropriate instructional strategy for a given learning objective;
- Identify the types of pedagogical approaches and associated technologies to suit particular types of learning.
- Provide advice on how to match types of pedagogical approaches and technologies to types of learning.

Main Learning Activities

1. Think about what kind of pedagogies that have been mentioned in this chapter that impact the selection of appropriate technologies. What other pedagogies can be added in the selection of appropriate technologies? What pedagogical approach has been used in this chapter? What additional strategies and technologies would you recommend to go with this chapter in a classroom setting?
2. Suppose you are planning to teach an 8-grade student about ocean tides (or another learning task of your choosing). Identify an appropriate learning objective for a lesson about ocean tides. Then indicate an appropriate pedagogical approach to support that objective. Next, consider affordable technologies that could be used to support such a lesson.

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3.1 Introduction

In this chapter, we argue that a theoretically consistent approach to learning design is to interrelate pedagogical theory with the desired features of learning, and then to map relevant activities and tools along with human and technical resources against learning goals and an appropriate pedagogical approach. This approach is intended to enable educational practice to reflect relevant learning theories. Different learning theories and epistemologies (e.g., behaviorism, cognitivism, constructivism) lead to various conceptions of information processing and knowledge development that influence effective technology use. Given the central functionality of education to help learners acquire and develop declarative, procedural and contextual knowledge, learning theories and technologies are fellow travelers.

The idea of linking learning theories and technologies became important as learning theories become more mature (i.e., cognitivism and social constructivism), and new technologies became affordable and commonplace (e.g., the Internet, social networking). The critical appraisal of the link between learning theories and technologies can be structured around the following observations: (1) changes in society and education have influenced the selection and use of learning theories and technologies; (2) learning theories and technologies are situated in a broad and ill-defined conceptual field; (3) learning theories and technologies are connected and intertwined with information processing and knowledge acquisition and development; (4) educational technologies have shifted in emphasis from program or instructor control toward more shared and learner control; and (5) learning theories and findings represent a complex mixture of principles and applications (Spector, Merrill, van Merriënboer, & Driscoll, 2008). In this chapter, the phrases "pedagogical approach" and "instructional strategy" are used interchangeably, although some scholars argue that there are differences in that learning includes non-formal situations as well as structured and formal learning situations.

3.2 Linking Instructional Strategies to Learning Objectives

3.2.1 Types of Learning Objectives

In the analysis phase of planning instruction, it is reasonable for a designer to consider the kinds of things to be learned (Anderson & Krathwohl, 2001). According to Gagné (1985), there are five different kinds of things that can be learned: (a) verbal information (e.g., facts, as in knowing that), (b) cognitive strategies (e.g., selecting a process to address a problem situation, as in knowing why and when), (c) intellectual skills (e.g., using rules to solve a problem, as in knowing how), (d) motor skills (e.g., riding a bicycle, as in performing well), and (e) attitudes (e.g., fascination with science, as in being interested in or inclined to) (see Table 3.1).

Table 3.1 Gagné's types of learning

Motor skills
• Behavioral physical skills
Verbal information
• Facts of knowledge
Cognitive strategy
• Metacognition strategies for problem solving and thinking
Intellectual skills
• Problem solving, discriminations, concepts, principles
Attitude
• Internal state affects an individual's choice of action

Further, there are four sublevels in intellectual skills: discrimination, concept application, rule using, and problem solving

Definitions

Motor skills: include physical skills and bodily movements involving muscular activity. Examples of motor skills are drawing a straight line, learning to ride a bicycle, changing a flat tire. Many motor skills also require verbal information, cognitive strategies, and intellectual. As it happens, nearly all of the five types of things to be learned involve some aspects of another learning type, but usually one type of thing be learned is dominant.

Verbal information: knowing that something is the case, for example, knowing that there are 24 h in a day or that tides occur twice daily; also known as, declarative knowledge. Examples of verbal information include knowing that insects have six legs or that a byte consists of eight bits (zeros or ones).

Cognitive strategy: refers to selecting an appropriate approach to solve a particular problem; a cognitive process that involves awareness of the problem as well as awareness of one's own knowledge and ability relevant to the problem, also known as contextual or causal knowledge. Examples of cognitive strategies include using a split-half approach to solving a troubleshooting problem or applying a bubble sorting algorithm for a selected data set.

Intellectual skills: Learning how to do something; also known as procedural knowledge. Subskills include discrimination, concept application, rule using, and problem solving; intellectual skills are also known as procedural knowledge. Examples of intellectual skills include solving equations, sorting objects into categories, and identifying relevant principles to apply in particular situations.

Attitudes: internal states which affect an individual's choice of action toward some object, person, or event. Example of attitudes is being predisposed to react in certain ways and having a particular interest in something.

Discrimination: Identifying things so as to be able to make different responses to the different members of a particular class. Examples of discrimination tasks include distinguishing different classes of objects, such as flowers, dogs, vegetables, and people of different nationalities.

Concept application: identifying and using appropriate concepts (both concrete and abstract concepts). Examples of concrete objects include chairs and tables. Examples of abstract objects include hate and social cohesion.

Rule using: applying a rule to a given situation or condition by responding to a class of inputs with a class of actions. An example of rule using is to multiple the probabilities of individual events to determine the probability of both events happening.

Problem solving: combining lower level rules to solve challenging problems. Solving problems is the aim of most learning tasks and the tasks are often complicated.

The main point is that the type of thing to be learned is an important aspect of instructional planning as it links to learning objectives, activities, outcomes, and assessments. The type of thing to be learned can help one identify a likely instructional method and strategy. There are, of course, other aspects to be taken into account, including the learners, their prior knowledge, and the setting in which learning will take place (see, for example, Eckel, 1993; Spector, Johnson, & Young, 2014).

3.2.2 Instructional Strategies and Types of Learning Objectives

An instructional strategy is a description of an approach to a particular instructional or learning activity. Instructional strategies are closely linked with the type of thing to be learned. For example, if the thing to be learned is how to remove the radar from an airplane, then it would not be appropriate to only use expository (i.e., telling) or inquisitory (i.e., asking) instruction. This is a procedural task that is best learned by showing and doing—of course, some information is necessary such as where the radar unit is located and what safety precautions must be taken. A strategy for learning such a task could be a combination of demonstrating and modeling the task, and then having learners perform the task, with feedback provided along the way. A variation could be breaking the task down into subtasks and using a part-task approach. For example, the first preparatory steps (e.g., turning off all systems and removing panels to gain access to the radar unit) might be treated as one chunk and practice until mastered. There are many instructional strategies that instructional theorists have developed over the years in addition to the general expository and inquisitory strategies mentioned earlier. Examples include the following (these are only meant to be suggestive, as alternative strategies might be appropriate for the instances cited and this list is far from exhaustive):

a. **Drill and practice**—appropriate for learning verbal information that for whatever reason must be committed to memory.
b. **Tutorial instruction**—appropriate for learning simple procedures or how to navigate within a particular software system.

c. **Exploratory instruction**—appropriate for promoting understanding about phenomena new to the learner.
d. **Interactive simulation**—appropriate for promoting critical reasoning about dynamic, complex systems.
e. **Socratic questioning**—appropriate for helping a learner link something new and seemingly unfamiliar to something already understood.
f. **Lecture**—appropriate for introducing a new topic and creating some motivation and an appropriate foundation for that topic.

Of course, there are many more strategies, and they can be applied in many ways. At a course level, the general approach might be an experiential strategy, but at the unit level a lecture might be effective to introduce basic concepts, and at the activity level, a case-based collaborative discourse or an interactive simulation might be effective. What is important is to align the strategy with the type of thing to be learned. Determining the appropriate strategy for a particular task is an important aspect of instructional design, as already mentioned multiple times. The designer takes into account various strategies suggested by an instructional theory and relevant learning theory, along with the type of thing to be learned and the learners involved, and then describes how to deploy those strategies in order to achieve optimal learning outcomes (Table 3.2).

Mastery Learning
The mastery learning model is based on the assumption that all students of a class can learn and attain the mastery level if sufficient time, adequate instruction, and timely help are provided to them according to their needs, interests, and abilities (Schwartz & Beichner, 1998). Therefore, the model focuses on attaining mastery level (i.e., grade A as an indicator of mastery of a subject) by almost all the students, say 95% of a class with due provisions of sufficient time and appropriate types of scaffolding and feedback (i.e., help; see Bloom, 1971).

Programmed Learning
Generally, the learning performed or instruction provided by a teaching machine or programmed textbook is referred to as programmed learning or instruction. Programmed learning is a method or technique of giving or receiving individualized instruction from a variety of sources such as programmed textbook, teaching machine, and computers with or without the help of a teacher (Schwartz & Beichner, 1998).

Simulation
Simulation is used as a technique for providing training to the students. Such type of instructional activities provides powerful learning tools to them (Schwartz & Beichner, 1998).

Table 3.2 Possible instructional strategies to types of learning objectives

Types of learning objectives	Possible instructional strategies/pedagogies
Motor skills	Drill and practice Part-task training Mastery learning Programmed learning Direct teaching
Attitudes	Role playing Scenario analysis Classroom Meeting Experience-based Learning
Verbal information	Drill and practice Tutorial Programmed learning Games lecture Mastery Learning Direct Teaching
Cognitive strategies	Exploratory learning Simulations Socratic questioning Group investigation
Intellectual skills—discrimination, Concept use	Drill and practice Tutorial Case study Lecture Inductive thinking (classification) Concept attainment Advance organizer
Intellectual skills–principles	Tutorial Exploratory learning Simulations Case study; Games; Lecture Debate
Intellectual skills—problem solving	Exploratory learning Collaborative learning Collaborative knowledge building Socratic questioning Project-based Learning

Direct Teaching

Direct teaching is the pedagogy that makes mastering academic knowledge and skills its central purpose. It can also be used to develop strategies for learning in a wide variety of content areas (Schwartz & Beichner, 1998). Behavioral pedagogical approach is appropriate for learning outcomes of motor skills and verbal information. Possible pedagogical strategies include drill and practice, part-task training, tutorial, games, lecture, and so on. For motor skill learning, possible strategies include hands-on experiences with real and simulated artifacts and interacting with simulations and virtual realities.

Inductive Thinking

The inductive thinking model is an example of concept formation based on allowing students to infer a general rule or patterns based on multiple examples and non-examples; this approach was developed by Hilda Taba (1971; see http://www.csus.edu/indiv/m/mcvickerb/imet_sites/fundamentals/inductive/taba_handbook.htm). Learning how to classify is fundamental; consequently, students learn information and concepts through the activity of classifying. They also learn how to build conceptual understanding of content areas and how to build and test hypotheses based on classifications. Inductive thinking is a generic model, partly because classification is believed to be the basic higher-order thinking skill and further, because the model is applicable to knowledge from phonics to physics.

Concept Attainment

The concept attainment model facilitates the type of learning referred to as conceptual learning in contrast with the rote learning of factual information or of vocabulary. In practice, the model works as an inductive model designed to teach concept through the use of examples. Therefore, in addition to help the students in the attainment of a particular concept, the model enables them to become aware of the process of conceptualizing.

Advance Organizers

As Ausubel maintains, advance organizers are the primary means of enriching or strengthening the learner's cognitive structure and enhancing the possibilities of learning or retention of new knowledge or information. Ausubel describes advance organizers as introductory materials or activities presented ahead of the learning task and at a higher level of abstraction and inclusiveness than the learning task itself. Their purpose is to explain, integrate and interrelate the material in the learning task with the previously learned material (Ausubel, 1968). Advance organizers increase the ability to absorb information and organize it, especially when learning from lectures and readings. Possible uses include learning cognitive strategies and intellectual skills (e.g., discrimination tasks, learning concepts, engaging in exploratory learning and simulations). Socratic questioning can be a form of an advance organizer. Possible technologies are management flight simulators, interactive simulations, and puzzles (Suchman's, 1964), an inquiry training system, or intelligent tutoring system, among others.

Group Investigation

Group investigation is a pedagogical approach that allows a class to work actively and collaboratively in small groups and enables students to take an active role in determining their own learning goals and processes. Examples for group investigation are observing the behavior of insects in groups, discovering the motion curve of an asteroid within a scientific team (Sharan & Sharan, 1990). Small group investigations are often used in problem-based medical training.

Classroom Meeting Strategy
The classroom meeting model is a multipurpose approach for classroom management by setting aside time for students to discuss classroom issues as a group. Examples of a classroom meeting model are holding class meetings to involve students in addressing question like "How should cheating be handled?" or "What can we do about teasing and bullying in our school?" (Class Meetings—TeacherVision, n.d.). While classroom instruction has been much criticized, it has a wide range of applicability.

Project-Based Learning Approach
Project-based learning is a pedagogical approach that encourages active learning within the constraints set by the teacher. Within this framework, students pursue solutions to non-trivial problems by asking and refining questions, debating ideas, making predictions, designing plans and/or experiments, collecting and analyzing data, drawing conclusions, communicating their ideas and findings to others, asking new questions, and creating artifacts. With the support of today's technology, project-based learning is making a strong comeback in the classroom. Throughout the process, students use digital tools for gathering information and multimedia to create learning artifacts. They are guided by what they think the end result of their project should be. The teacher coaches the team to keep students on task and keep their work productive while students develop self-management and collaboration skills. By providing peer feedback on the content and demonstrating respect for their own findings, more substantive content is learned. The end product of each team is often presented to the whole class, demonstrating their understanding of what they learned.

Inquiry-Based Learning Approach
Inquiry-based learning approach is a method with which students learn knowledge driven by specific questions or a complex problem. The teacher scaffolds and helps students as they make contributions, identify questions, and gather relevant data on the Web. The setting of the problem is crucial during this process.

Collaborative inquiry holds process similarities with project-based learning although it is distinctive in its focus on a driving question, or a complex problem, with respect to which students gather data for later analysis. In inquiry-based learning, the setting of the problem is as important as, if not more important than, finding solutions. The teacher scaffolds and helps students as they make contributions, identify questions, and gather relevant data on the Web. With mobile technologies, data from the field become more easily accessible with analytic tools to make sense of what has been gathered.

Possible technologies to support the constructivist approach include toolkits and other support systems. Access to resources and expertise offers the potential to develop engaging, student-centered, active and authentic learning environments; Microworlds and simulations are likely technologies.

Collaborative Learning

Collaborative learning is broadly defined as a situation in which two or more people attempt to learn together (Dillenbourg, 1999) or to accomplish shared goals (Johnson & Johnson, 1986). Characteristics of effective collaborative learning include positive interdependence among members, group and individual accountability, interpersonal skills, the ability to self-monitor, ensure consistent progress, and discontinue patterns of behavior that impede the progress (Johnson & Johnson, 1986). Collaborative learning is a situation in which two or more people learn or attempt to learn something together. Examples for collaborative learning are parents completing a task with their kids, participating in community economic activities (Collaborative Learning, 2017). Small groups of 3 to 5 learners are often effective, and on occasion, roles may rotate among the members of a group to ensure that everyone learns all aspects of the task (Johnson & Johnson, 1996).

Collaborative Knowledge Building

Collaborative knowledge building focuses on problems and depth of understanding; it takes steps of the creation, testing, and improvement of conceptual artifacts in groups. Knowledge building represents an attempt to refashion education in a fundamental way, so that it becomes a coherent effort to initiate students into a knowledge creating culture. Accordingly, it involves students not only developing knowledge building competencies but also students coming to see themselves and their work as part of the civilization-wide effort to advance knowledge frontiers. In this context, the Internet becomes more than a desktop library and a rapid mail delivery system. It becomes the first realistic means for students to connect with civilization-wide knowledge building and to make their classroom work a part of it (Sardamalia & Bereiter, 2014). Examples of knowledge building are group discussions, interactive questioning, dialogue, and so on.

3.3 Types of Technology for Educational Uses

Technology

According to Rogers (1995), a technology is a design for instrumental action that reduces the uncertainty in the cause-effect relationships involved in achieving a desired outcome. Others define a technology as a systematic application of knowledge to solve a problem valued by a group or society. In both cases, the aim of a technology is to achieve a desired outcome.

A technology may have two components: (1) a hardware aspect, consisting of the tool that embodies the technology as a material or physical object, and (2) a software aspect, consisting of the information base for the tool. Some technologies lack one or both of these components and may simply consist of a standard procedure or general purpose algorithmic approach.

Educational Technology

Educational technology is not a homogeneous intervention but refers to a broad variety of modalities, tools, and strategies for learning. Its effectiveness, therefore, depends on how well it helps teachers and students achieve the desired instructional goals (Bruce & Levin, 1997).

Bruce & Levin (1997) describe a new way of classifying uses of educational technologies, based on a four-part division suggested years ago by John Dewey (1938): inquiry, communication, construction, and expression. Each of these is briefly described next.

3.3.1 Technologies for Inquiry

What follows are lists of technologies, tools, and techniques likely to be appropriate to support inquiry.

- Theory building technology as media for thinking
- Model exploration and simulation toolkits
- Visualization software
- Virtual reality environments
- Data modeling-defining categories, relations, representations
- Procedural models
- Mathematical models
- Knowledge representation and integration tools such as semantic networks, and outline tools
- Data access connecting to the world of texts, video, data
- Hypertext and hypermedia environments
- Library resources
- Digital libraries
- Databases
- Repositories with music, voice, images, graphics, video, data tables, graphs, text, etc.
- Data collection using technologies to provide enriched input
- Remote scientific instruments accessible via networks
- Microcomputer-based laboratories, with sensors for temperature, motion, heart rate, etc.
- Survey makers for student-run surveys and interviews
- Video and sound recordings
- Data analysis methods and technologies
- Exploratory data analysis
- Statistical analysis
- Environments for inquiry
- Image processing

- Spreadsheets
- Programs to make tables and graphs
- Problem-solving programs.

3.3.2 Technologies for Communication

- Document preparation
- Word processing
- Outlining
- Graphics
- Spelling, grammar, usage, and style aids
- Symbolic expressions
- Desktop publishing
- Presentation graphics
- Communication with others
- Electronic mail
- Asynchronous computer conferencing
- Synchronous computer conferencing (text, audio, video, etc.)
- Distributed information servers like the World Wide Web
- Student-created hypertext environments
- Collaborative media
- Collaborative data environments
- Group decision support systems
- Shared document preparation
- Social spreadsheets
- Teaching media
- Tutoring systems
- Instructional simulations
- Drill and practice systems
- Telementoring (see http://elatewiki.org/index.php/Telementoring).

3.3.3 Technologies for Construction and Problem Solving

- Lego components, tangram puzzles, Rubik's cube
- Computer-assisted design software
- 3D printing.

3.3.4 Technologies for Knowledge Representation

- Sensors and using technologies such as QR Codes, GPS displays
- Graphs and charts

- Drawing and painting programs
- Music making and accompaniment
- Music composing and editing
- Interactive video and hypermedia
- Animation software
- Multimedia composition.

3.4 Principles for the Selection of Technology for Educational Uses

Mayer (2009) has proposed some principles of multimedia learning which can also be used for guiding the selection of technology for educational uses. The principles are as follows:

(1) **Principle of Appropriateness**

- Technology should promote the general and specific goals of the class.
- Technology should be appropriate to the intended level, including vocabulary level, difficulty of concepts, methods of development, interest appeal.
- Technology should be either basic or supplementary to the curriculum.

(2) **Principle of Authenticity**

- Technology should present accurate, up to date, and dependable information.

(3) **Principle of Cost**

- Substitutes and trade-offs of alternative solutions should be considered.

(4) **Principle of Interest**

- Technology should catch the interest of the learners, must stimulate curiosity, or satisfy the learner's need to know.
- Technology should have the power to motivate, encourage creativity, and imaginative response among users.

(5) **Principle of Organization and Balance**

- Technology should be well organized and well balanced in content.
- Purpose of the material should be clearly stated or perceived.
- There should be logical organization, clarity, and accordance with the principles of learning such as reinforcement, transfer, and application in the materials.

Key Points in This Chapter

(1) The kinds of instructional strategies that should be selected depend on learning objectives and learning domains; the technologies should be aligned with instructional strategies.
(2) In order to achieve the learning objectives, learners engage in learning activities, such as inquiry, communication, construction, and knowledge representation. Types of learning and pedagogies should be considered when selecting appropriate technologies.
(3) Pedagogical approaches relevant to the selection of technologies include practice and feedback approaches, representational approaches, collaboration approaches, project-based approaches, inquiry-based approaches, and informal and autonomous learning approaches.
(4) The principles for the selection of technology educational uses include the principle of appropriateness, the principle of authenticity, the principle of cost, the principle of interest, and the principle of organization and balance.

Learning Resources
Additional reading materials for project-based learning and inquiry-based learning:

The works of researchers Ronald W. Marx, Phyllis C. Blumenfeld, and Joseph S. Krajcik on 02/tea.3660020315project based science in the Detroit (MI) schools are a good example of a combination of both approaches.

http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.458.4719&rep=rep1&type=pdf

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