

# Instructional Design Tips for Virtually Teaching Practical Skills

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## Abstract

What can you do to virtually teach the hands-on skills traditionally taught in labs? If you include simulations, active experimentation, discovery-learning techniques, numerous questions with detailed feedback, video, animations, and photographs, you can effectively teach practical hands-on skills through multimedia technology. Through discussion and demonstration, this session will highlight practical tips for implementing the instructional development cycle as well as uncommon but effective instructional design strategies for teaching practical skills. Some of the highlighted programs (such as a virtual chemistry lab) have pushed the boundaries of what can be accomplished with multimedia technology. By the end of this interactive session, participants (who can range from novices to experts) should be able to identify computer-based training applications that effectively use multimedia technology, generate examples of where new media technology can be appropriately used to virtually teach hands-on skills, and decide where to incorporate the strategies shown into their computer-based training productions.

**Keywords:** virtual lab, practical skills, instructional design, computer-based training, interactivity

## Introduction

Many of the challenging computer-based training projects undertaken by the Group for Advanced Information Technology (GAIT) at the Technology Centre of the British Columbia Institute of Technology have taught practical skills. These projects have been initiated because clients or instructors have identified those areas as being problematic. In other words, there are some significant limitations when the skills are taught via traditional methods. There are numerous limitations:

- Learners may not be able to attend teaching/training locations. This is an inherent problem in distance education. Many learners can learn the theory online or through other distance education solutions. However, they may not be able to learn the needed practical skills at a distance. Virtual labs can solve this problem. A demonstration version of a product that teaches both the theoretical and lab components of the reaction kinetics portion of high school chemistry can be downloaded from <http://www.tc.bcit.ca/gait/projects/chemistry.shtml>

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- There may be an inability to teach some content well such as topics requiring simulations. For example, one project was teaching piping students how to test and troubleshoot backflow prevention assemblies. A demonstration version of this project can be

downloaded from <http://www.construction.bcit.ca/trades/piping/computertraining.shtml>

- Logistical challenges can also be problematic such as when experts do not have enough time to travel around the country to teach (i.e., their fulltime job does not leave them with enough time to provide training). One project entailed capturing the expertise of personnel in a spinal cord injury centre of a major hospital on how to move and turn patients with a spinal injury. The resulting program was then freely distributed on CD-ROM and web download to those who needed the training around the world. This award-winning project can be freely downloaded from <http://www.tc.bcit.ca/gait/projects/spinal.shtml>
- Costs for live training can be prohibitive such as when numerous participants are required to travel to a workshop. One project involved training aircraft mechanics. Costs typically included salary for one day to travel to the workshop location, two days at the workshop, and one day to return home as well as travel, accommodation, and per diem expenses. The resulting CD-ROM allowed mechanics to learn when and where they wanted in approximately one-quarter of the time needed in the workshop.
- Equipment can be a limitation. For example, one way to teach troubleshooting involves taking components out of functioning systems, breaking them, putting them back in, and letting students determine the problem. However, this is impractical because of the time it takes to remove, break, and install components, the cost of later repairing the components, the problem that this needs to be done to many components, and the time required to have all of the students individually determine the problem for each broken component. One simulation was created to address this type of equipment limitation. It entailed teaching piping students how to troubleshoot hot water heating systems. A demonstration version of this project can be downloaded from <http://www.construction.bcit.ca/trades/piping/computertraining.shtml>
- There may be a requirement for just-in-time learning. One common example is when instructors are hired in post-secondary settings. It is not unusual for the individual to have had no training in how to teach as they are mainly hired for their subject matter expertise. However, they often have to begin teaching before a workshop is available or any formal training can be delivered. GAIT is currently developing a highly-interactive product to deliver basic instructional skills where and when an individual needs it.

The instructional challenge in these projects has been to ensure that the practical skills taught via the computer transfer to the real world. There is evidence to support that this can be done (Fenrich, 2002).

Note that, in this context, virtual labs simulate and teach what learners must do in traditional settings. A virtual lab is not created simply because one has transferred their lab workbook to a website.

## **Problems with Teaching Practical Skills in Traditional Classrooms**

There can be numerous problems when teaching practical skills in typical classrooms and labs:

- When a demonstration is done, some students may not be able to clearly see what is being demonstrated (e.g., those in the back of the class).
- Many instructors will not show all of the possible demonstrations (due to time or cost considerations).
- In many cases, if a student misses an activity, they will not be able to do it later.
- Students are often not able to repeat an activity if something goes wrong.

- Dangerous, expensive, or unavailable equipment or materials may limit what learners can see or do.
- Quite often, media is needed to teach practical skills. Existing media may not be easily shown when and where a student needs it. For example, a repairperson may need to see video clips while they are working on the equipment rather than in the classroom itself.
- Some existing traditional teaching materials are not effective. For example, a 20 minute videotape was created to teach mechanics how to disassemble an aircraft engine. However, the total disassembly requires approximately 100 steps. A better instructional solution would have included step-by-step short video clips and text explanations.
- Even if a student is fortunate enough to be taught with media (when it is instructionally required), questions and feedback are often delivered via text. In many cases, if the content needs to be taught with a variety of media, effective testing requires a variety of media.

Given solid instructional design strategies, multimedia technology can and has solved these limitations.

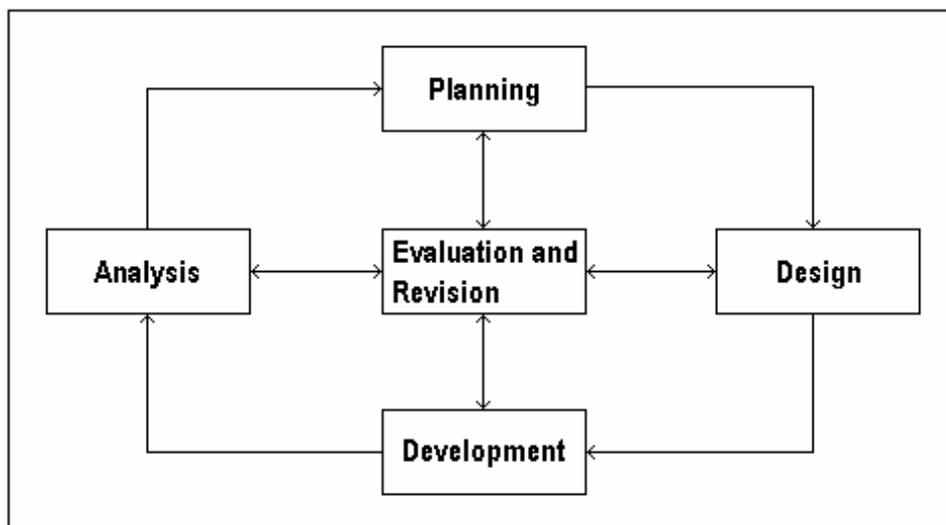
## Instructional Development Cycle

In general, the design and development of software that teaches practical skills (as with other types of instructional software) should follow an iterative instructional development cycle as illustrated in Figure 1. The presented instructional development cycle is adapted from Spitzer (1991). Following the instructional development cycle is essential in helping create effective products. Many projects have failed because steps in each phase have not been followed or were not done well enough.

### ***Analysis Phase***

The initial purpose of the analysis phase is for you to define the actual problem and then determine whether the problem needs an instructional multimedia solution. The analysis phase should provide you with a concise problem definition and initial cost estimates (Fenrich, 1997).

The time invested in the analysis phase tends to save more time throughout the rest of the process.



**Figure 1: Model of the Instructional Development Cycle**

If you do not spend enough time properly defining your learning outcomes, the entire subsequent development could be for unneeded skills. For example, be sure to identify the actual problem rather than symptoms of a problem. The symptom may be a refusal to use a software program because the “program does not work” but the real problem is a fear of the technology. So, an instructional solution aimed at how to use the software could be a wasted effort.

Well-written learning outcomes help to keep the subsequent instructional development process on track. When in doubt, always refer back to the stated learning outcomes. It is often tempting to cover interesting but unneeded or non-funded topics. For learning outcomes, also consider what the learner really needs to learn rather than what one wants to teach. For practical skills, imagine what the learner really needs to do. For example, in some cases in the laboratory portion of chemistry, the learner does not really need to pour one chemical into another. The important skills may be the observations, data analysis, and conclusions that are drawn.

### ***Planning Phase***

The planning phase helps your whole project proceed smoothly. A major component of the planning phase involves identifying and addressing potential problems. Other major planning tasks include assembling the team and setting timelines (Fenrich, 1997).

Problems could be a lack of acceptance from all levels (e.g., for creating a virtual lab, some individuals may feel threatened by its creation), inexperienced team members, lack of development tools ... If you are attempting to create a complex simulation, such as a virtual lab, it is even more important to have all potential problems solved before investment in design and development have begun.

### ***Design Phase***

Based on your problem definition and the stated learning outcomes, the design phase leads you to creating the instructional strategy - what needs to be done to ensure that the students will effectively and efficiently learn. Another component of the design phase is to define the standards and needed utilities so that programming can begin. In this phase, create programming sub-routines and templates. These can save an enormous amount of time during the development phase. A last step is to finalize all of the resource requirements (Fenrich, 1997).

As much as possible, to save time and money, base new projects on templates and subroutines that have been created for other computer-based training applications. However, do NOT compromise learning simply for the convenience of using templates. You should expect that only a limited amount of a virtual lab will follow existing templates.

Design an intuitive user-interface based on the philosophy: “If you have to explain how to do it, you have done something wrong.” An intuitive user-interface is particularly important in virtual labs and other simulations. Too many existing simulations have had minimal results or have failed due to their complex user-interfaces.

Determine how to guarantee effective learning! This is a particular challenge when students are on their own and cannot have their questions immediately answered. “Think outside the box” to guarantee learning. Consider simulation, discovery-learning techniques, and active experimentation. “Page-turning” activities will not suffice for learning some practical skills. Use the technology for its strengths rather than simply transferring content from one format to another!

Different learning outcomes may need different instructional strategies. No one strategy will successfully teach all learning outcomes. Again, “think outside the box”. Consider including simple games to teach practical skills. Games provide a fun way to learn.

Organize the information into small enough chunks for the students to successfully learn. For example, if the procedural skill has numerous steps, consider teaching them in logical groups of between three to six steps. Many instructional resources provide too much information for students to learn at one time.

Base some of the content on the potential for making mistakes. Ask the content expert about typical mistakes made after the content is taught in the traditional way. If one only teaches what is correct, the learner may never learn what can go wrong. For example, this is important in teaching physicians how to make an accurate diagnosis.

To address a variety of learning styles, teach with a variety of different methods and media. No one single teaching method or medium is perfect for all learners (McCarthy, 1987). Note also that teaching with more than one medium is usually more effective than teaching with only one medium (Romiszowski, 1988). Teaching practical skills via computer usually requires a variety of media. Use media to enhance learning. Do NOT include media (e.g., animations) simply because it can be done. It can be a significant waste of resources. This is a particular concern when resources are limited.

Note that test questions can include media that are similar or identical to those used in the presentation. Assume that if the content needs to be taught with media, the content should be tested with media. For practical skills, it is likely easier to test with a photograph or video clip than text alone. Remember that a picture is worth a thousand words. This is particularly true for hands-on skills.

Determine whether testing is realistic enough and a true performance measure. This is particularly important for practical skills. When testing, consider all difficulty levels. Many existing computer-based training packages are weak in that they only address low-level thinking skills.

Make the program highly interactive throughout! Interactivity is active participation in the learning. Interactivity requires the learner to think (Fenrich, 1997). Choosing menu items is navigation. Always provide detailed feedback, even when the answer is right. This is in case the student guessed the correct answer or answered correctly for the wrong reason(s).

Encourage students to work in pairs. This is beneficial for extroverts who may otherwise be reluctant to learn via computers. Also, when answering questions, students often discuss the answers especially when they disagree on which answer is correct. (This leads to increased learning.)

## ***Development Phase***

The development phase leads you through creating a storyboard representing the instructional strategy, finalizing the media selection needed to teach the material, and then developing and programming the materials (Fenrich, 1997).

When developing the media, remember that the quality of professionals often shows – it may or may not matter but it usual shows. Follow the maxim that “you get what you pay for”.

Using an authoring tool, all of the content must be transferred into a computer program. If the programming shell and templates are designed well, much of this effort can be little more than a cut and paste activity. However, instructional strategies that are relatively unique, such as those needed in virtual labs, often do not fit within typical templates. However, once something is programmed once, many variations can be relatively easily created.

## **Evaluation and Revision Phase**

Evaluation is the systematic collection and analysis of information to aid in decision making and planning. A large amount of the evaluation should be done on the paper-based storyboard by content experts and, if possible, by target audience learners. It is easier to make changes on paper than on the authoring tool. After this, both the learner's hardware systems (e.g., monitors, memory, computer speed, sound boards ...) and the created software must be evaluated. Keep the following adage in mind, "It is impossible to make things foolproof because fools are so ingenious." Base revisions on the evaluation feedback and data. A major strength of this instructional development cycle model is that evaluation and revision are ongoing throughout the process. This helps prevent changes from becoming too expensive.

## **Discussion**

By carefully working through the instructional development cycle, following sound principles of instructional design, and determining innovative instructional strategies, practical skills can be taught virtually. When taught well via multimedia technology, hands-on skills can transfer to the real world. This does not at all imply that all practical skills can or should be taught only with multimedia technology. The reality is that students do indeed need to practice what is taught in a real setting. From a realistic perspective, virtual learning can solve some instructional problems. In some cases, students can learn all they need virtually. In other cases, virtual learning can reduce the amount of time a student needs to spend practicing skills in the traditional lab setting. Multimedia technology, in particular the creation of virtual labs, can greatly impact distance education initiatives!

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## **Biography**

**Peter Fenrich.** Since 1984, Peter has been designing and developing instructional new media products at the British Columbia Institute of Technology (BCIT). His duties include leading projects, writing proposals, designing and developing instructional new media software, conducting research, giving presentations both locally and internationally, training, leading workshops, and evaluating software. His work has been recognized with national and international awards.

Peter teaches a course, both at BCIT and internationally, that he created entitled "Creating Multimedia Instruction". In 1997, Harcourt Brace published his accompanying textbook to the course. Peter also taught secondary school science and mathematics in Nigeria for two years.