Instructional Design Strategies for Instructional Technologies Utilizing Data Visualization

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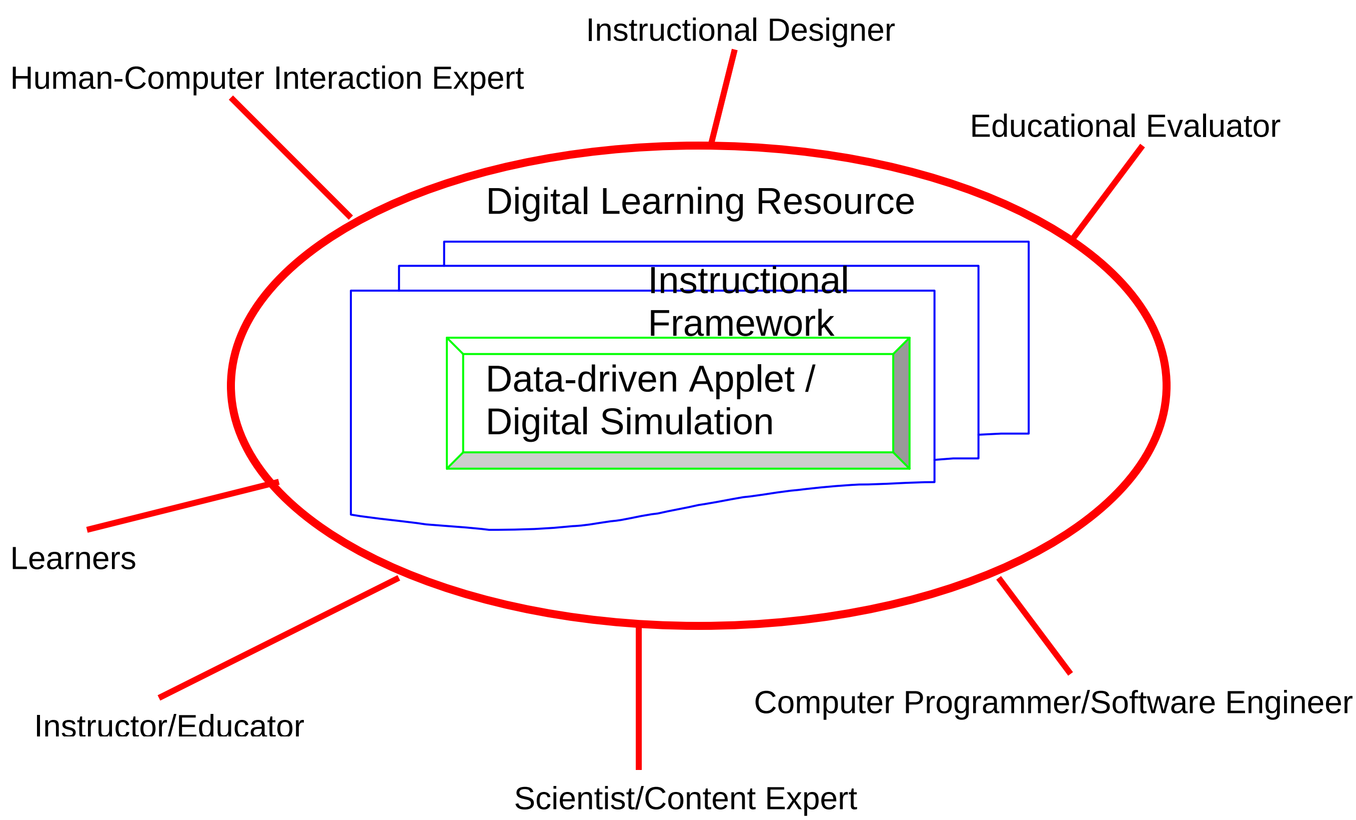
"Digital learning resources" are the latest craze in the instructional technology community. They are self-contained, useable in many different contexts, and students can access them anytime and anywhere there is an internet connection. Astronomy is a natural fit with digital technologies – CCDs, image processing, super computer applications, simulations, etc. How can we bring these great digital tools effectively into a learning environment? Who develops it? Who will use it?

The schematic below shows the basic ingredients to the development of a digital learning resource. In a perfect world, there would be 7 distinct experts working on the project. In reality, it's usually one or two, and they are most likely the content expert (astronomer) and the computer programmer/software engineer. They may not specialize in user interfaces or instructional design, but will have a good inkling. However, they may not know the best path to take nor the latest in science education research or educational pedagogy. These are important ingredients and are essential to the overall success of a digital learning resource. As described later, there are many places that education specialists can be found and numerous ways to consult and collaborate. The purpose of this paper is to help others become aware of what goes into the instructional design of a learning resource, buzzwords that you can Google later on, and an outline of a path to start down.

Anatomy of a Digital Learning Resource



Human-Computer Interaction (HCI) Expert: Designs and/or evaluates the user interface of the digital learning resource. Ensures that navigation and ease of use is intuitive and transparent so that technology does not interfere with learning.

Instructional Designer (ID'r) Expert:
Designs and evaluates the instructional framework that wraps around the computer simulation using appropriate educational methodologies and pedagogies.

Education Evaluator:
Evaluates the end-product after it is disseminated and used in both formal and informal learning environments. Informs the project leader with formal feedback and suggestions for improvement which enables the project leader to apply for more funding.

Instructor/Educator:
Implements the digital learning resource in formal and/or informal learning environments. Tailors the instructional framework to the specific needs of his/her subset of learners.

Learners:
Through the instructor/educator will use the digital learning resource to discover new knowledge and understandings in a specific content area.

Scientists/Content Expert:
Give content-correct knowledge and understanding to the design team. Helps to identify areas of possible misconception and vague content within the computing application.

Computer Programmer/Software Engineer:
Designs and implements the computing application, the heart of the digital learning resource.

How to Get Started

So, you have a nifty computer simulation and you want to bring it into an educational setting? What do you do ? Read on for some advice on the essential beginning steps.

1. Talk to instructors/educators in the content area.
You need to determine if your cool digital resource and specific content topic are appropriate as a digital learning resource for a given audience of learners. Not all data-driven applets and computer simulations are appropriate for use as an educational tool. You have to consider the possible obscureness of your content topic or the amount of prerequisite knowledge held by the user.

2. Find an instructional designer or instructional technologist for consult.
The expertise of an instructional designer/technologist will help guide the development, implementation, and evaluation of your educational project. They can set you on the right path, help you better form ideas, and point you towards valuable resources you may not know exist. Look in your own university or college for these individuals. Such places they hide are libraries, learning centers, faculty development centers, colleges of education, academic departments like instructional systems, instructional technology, and educational psychology. If you are not in an academic setting, contact your local higher education institution and form a new collaboration.

3. Seek out a science education specialist.
You will find these folks in the College of Education. They specialize in how people learn science, the obstacles to learning science, best practices and methodologies in teaching science, and the extent

to which certain content topics can be covered at various grade/age levels. There may even be an interested master's or doctoral science education student looking for an independent study!

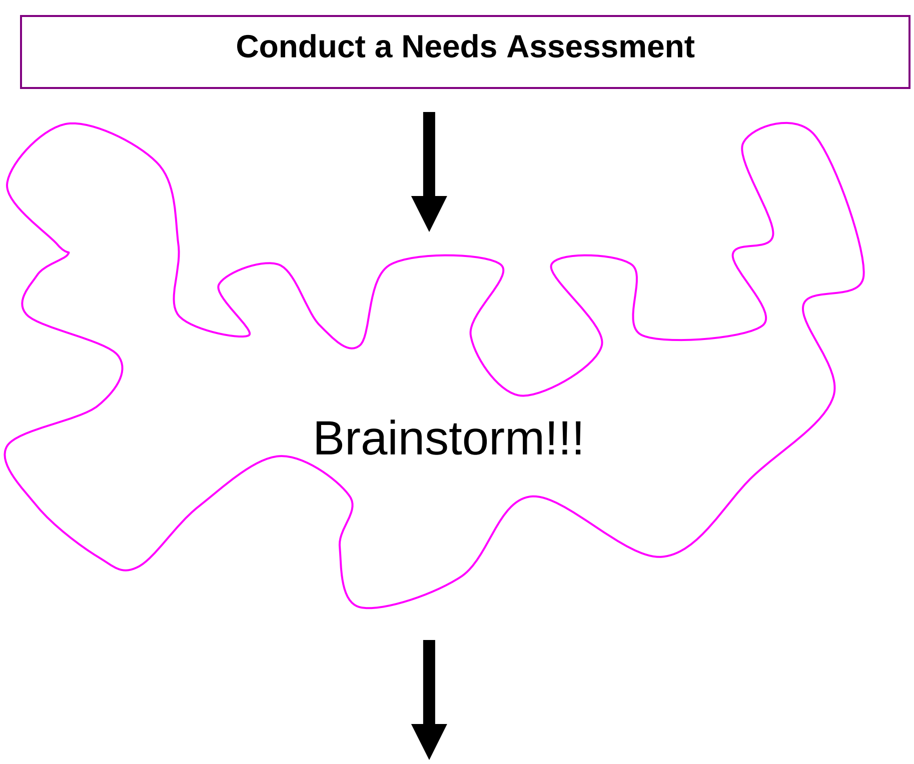
4. Collaborate, collaborate, collaborate!
Don't be one of those overwhelmed scientists or programmers who has to wear every hat on the project! Developing an entire educational tool by yourself could lead to much stress and frustration. Also, NSF likes to see cross-departmental collaborations so it will help when it comes time to apply for funding for your educational project.

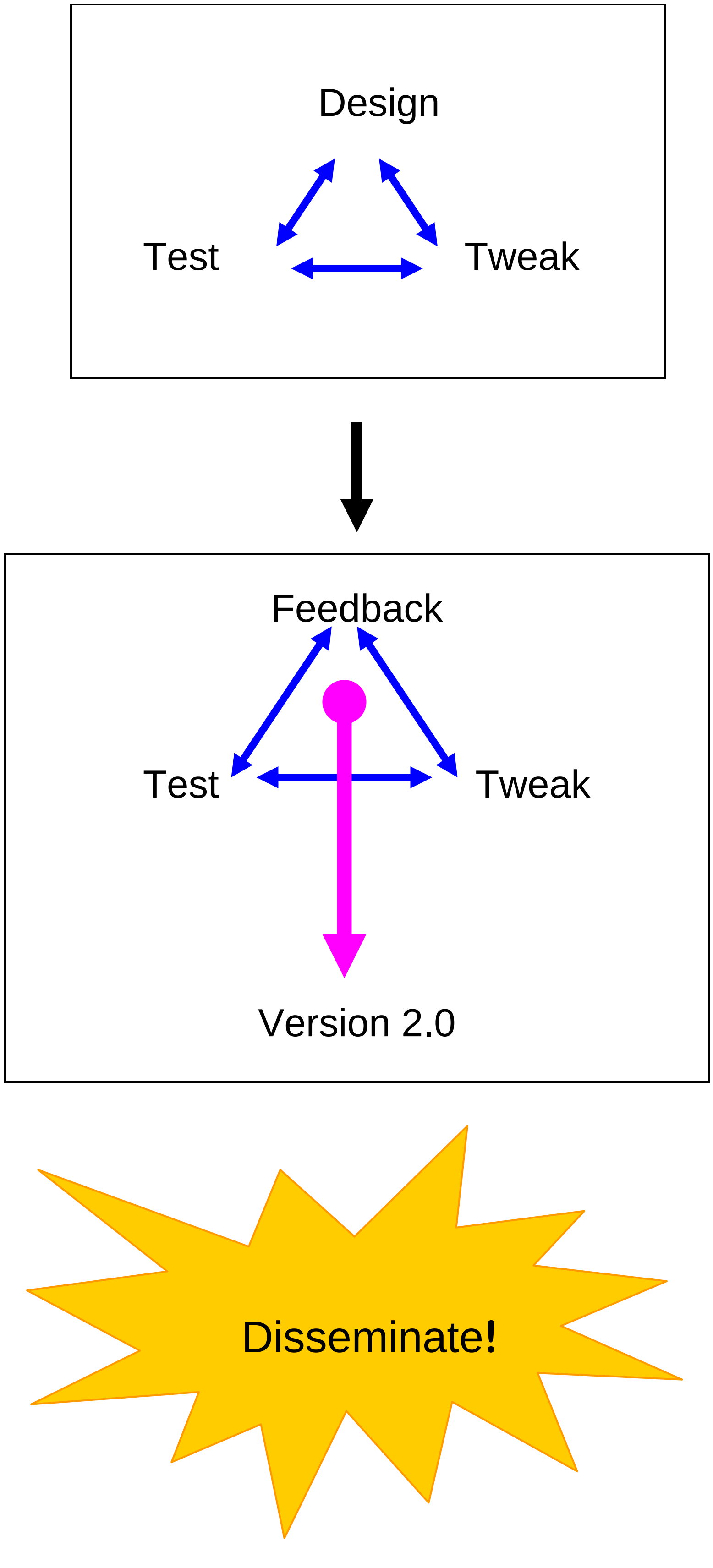
5. Accept the fact that you will evaluate and tweak and reassess and tweak some more and that it's a never ending process, before you begin development.
Digital learning resource development, at it's best, is an iterative process that requires testing and evaluating with end-users and outsiders. Feedback is essential and must be listened to and assessed.

6. Shout out to the world that you have created a masterpiece!
Advertise the existence of your digital learning resource widely. "If you build it, they will come" is just not true. When you go to a science or programming conference, present in the education component. Put out an announcement in online journals, like AER (Astronomy Education Review) or showcase it on your own campus to other interested faculty.

"A Bit Backwards" Instructional Design

Instructional design (ID) usually begins by not having any specific instructional tools in mind. But, you already have a tool that you want to become a learning experience. Thus, the instructional design process is a bit backwards, but that's okay. The general ID model will still work for you and help you organize, structure, and guide your project.




Design
Test
Tweak
Feedback
Test
Tweak
Version 2.0
Disseminate!

Needs Assessment:

This is an essential first step as it will guide the focus of your education project.

- In what setting will your digital resource be used? (K-12, higher education, museum or science center)
- Identify who will use your digital learning resource.
- How do you think they will use it?
- What technology/computing skills do the users have? (included in this are learners and instructors)
- What is the prior knowledge of the content topic they will have?
- What are your first ideas of what the general learning goal will be?
- Is your computing application appropriate for educational use? Is it too abstract or vague? How can you tailor it to be wrapped in instruction?
- How does the content of your learning resource fit into national standards for education?

Gather and summarize your needs assessment answers for when you gather the masses for the next step.

Brainstorm:

This is no-holds-barred "perfect world" brainstorming! Be sure you have a content expert and an education specialist here for this step. Go crazy thinking of all kinds of ways your computing application can be used in a variety of educational settings. Worry about the real-world concerns later.

Design:

After a bit of creative brainstorming above, you can better determine what is feasible and can begin planning the design of the instructional wrapper for your computing application. You should consult with an instructional designer at this point. You can find such folks at universities, in academic departments, and faculty resource centers. They can help you sort out the design process and define learning goals. Instructional and learning goals are very important, otherwise, how will you know if your digital learning resource is doing its job? Ask yourself, "what exactly would learners be doing if they were demonstrating that they could already perform the goal?"

Additionally, you need to define pre-requisite knowledge needed to use your tool. Are there gaps between what the learners will know coming in and the pre-requisite skills? How can you fill that gap so they can effectively use your resource?

Another important aspect of the design process is to pick an educational pedagogy/method to use. Looking into and talking with an education specialist or instructional designer about instructional strategies is a definite must. There is a whole science dedicated to learning (it's actually called learning science and is usually found in the educational psychology arena). You may have a good idea about how to write an activity, but you really have to walk the walk if you are talkin' the talk. Designing an activity around sound pedagogy will make your resource stronger and will help you get grant money.

It may seem like a small detail in the grand scheme of the project, but some time has to be put into the design of the interface. If a user has trouble using the resource, frustration and impatience take over and learning halts. It's important to have a clear, simple, and intuitive interface.

The Iterative Process:

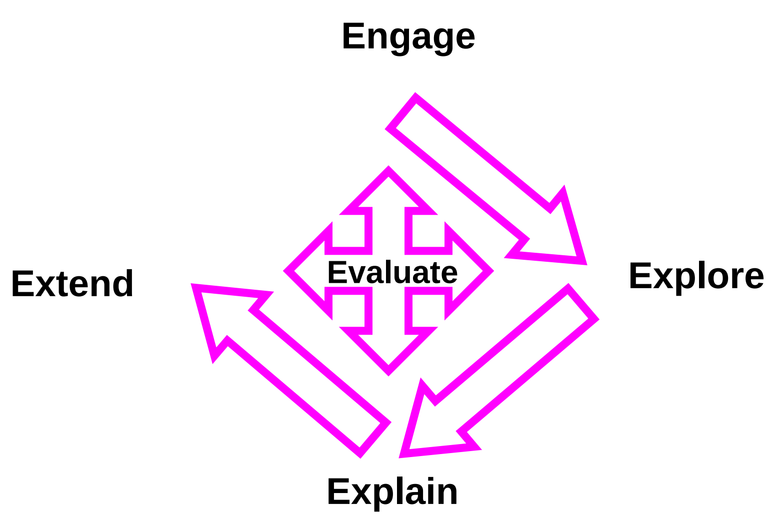
Instructional design is an iterative process. After the initial version is created and is working, it needs to be tested and evaluated by the end-user. This can be done in small groups and there are a variety of methods to use. After you receive feedback from the users, you will return to the design process and tweak. And then test again, and then tweak, and test, and tweak…you get the idea.

The project will never “be done”, but it will reach a point where you can boast about it, present at conferences, let wider audiences use it, and such. There is light at the end of the tunnel!

Constructivism

Let’s ponder for a moment on what scientists do. They take some base knowledge about a topic and they find something intriguing about a new “phenomena”. They form questions and hypotheses and they experiment until they have formed new understanding. The previous phenomena has evolved into a discovery.

This is a constructivist mentality! You’ve been doing it all along and you didn’t even know. Many science educators believe students, and learners of all ages and in all environments, should be doing this “discovery learning” to better understand science and the world around them. There are many models and many approaches to implementing constructivist frameworks. Here you are shown a popular application of “active and cooperative learning”; the 5 E’s Learning Cycle.



Active & Cooperative Learning:
Learners work together to solve problems, formulate and answer questions, discuss, debate, brainstorm, and actively participate in the construction of their own understandings. There are both individual and group accountability built into the activity.

The 5E’s Learning Cycle Method:

Step 1. Engage
Interest in the content topic is generated and general curiosity is raised. Questions such as, “what happened?”, “how did that happen?”, and “how can I find out?” are encouraged.

Step 2. Explore
Working in small groups, learners work together without direct intervention from the instructor. Learners are allowed to explore, within limits, as the instructor takes on a facilitator role. Learners should be experimenting, exploring, hypothesizing, and observing.

Step 3. Explain
Learners should be able to explain their explorations and observations in their own words. There should be peer review built into the instructor led discussion. Instructor (or digital learning resource) should provide feedback, answers, and a general pointing in the correct direction.

Step 4. Extend
Learners are asked to apply their limited, yet correct, understandings of the content in a new, but similar, situation as they deepen their understandings.

Ongoing. Evaluate
Throughout this model, the instructor (or digital resource) is asking questions and obtaining feedback in order to better guide the learner's exploration. The learner needs feedback throughout this model as they are asked to self-reflect on how their thinking is changing through the course of the activity.

In Closing

I hope you found this handout helpful! Even if you are only the science visualizer, you may be part of a group where instructional development is taking place. Please pass on this handout to others who may be interested in designing instructional wrappers for your data visualizations. I am open to talking about collaborations or consultations, so please do not hesitate to contact me.

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