Universal Learning Design:
A View from Conceptual Goals to the Actual Implementation

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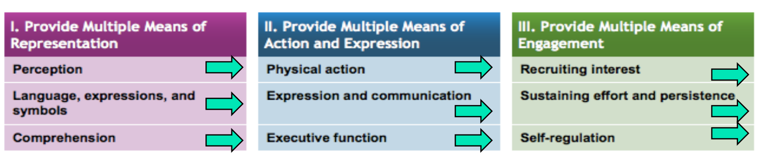
Introduction

- **Universal Learning Design**
  is a set of principles for curriculum and teaching tool development that gives "all" individuals equal opportunities to learn.

Primary Principles of ULD



- Well distributed and well accepted
- Interpretation of the guidelines is not absolute dogma, but open to some discussion

Primary Principles of ULD

- But!
  - How close can we get?
  - How do we verify their validity?
  - It seems VERY hard to achieve the principals at a high level implementation,
  - If, instead, how can we be sure that all of the low level implementations as a "system" meet the principals?

Introduction

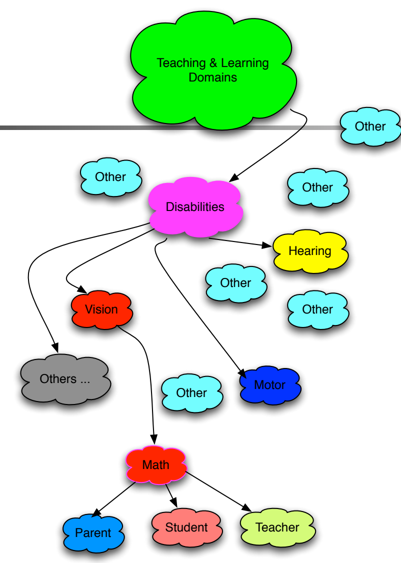
- The discipline provides a blueprint for creating instructional goals, methods, materials, and assessments that work for everyone--not a single, one-size-fits-all solution but rather flexible approaches that can be customized and adjusted for individual needs
- As we say in the US, this is a "tall order."

Introduction

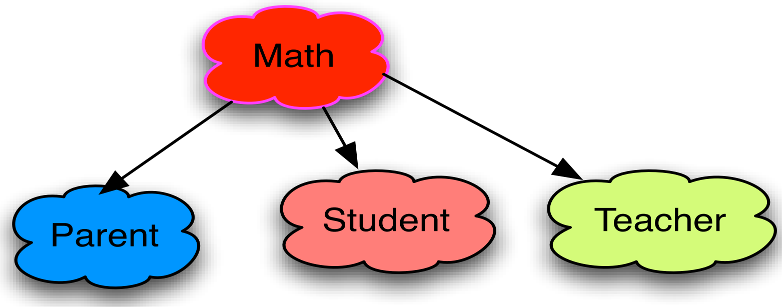
- Unfortunately the complexity of the problem tends to make the goal a target, but most likely not achievable.
- The diversity of the teaching, learning and helping devices represent a huge and disparate group of teachers, parents, students and tools

Introduction

- Matching all of the possible combinations and permutations of the participants "probably" can not be achieved on the macroscopic level
- Having said all of this, let's look a bit more deeply at a more microscopic domain associated with the general concepts associated with ULD.



Our Specific Micro World will be…



The Disabled Population in the Educational System

- Having left the macroscopic world, and entering a microscopic world of education of the disabled, we find that
  - We have entered another macroscopic world
  - For today's talk, we will use our zoom lens to focus more deeply in our new macroscopic domain – students with disabilities

The Disabled Population in the Educational System

- We're not done yet. Our zoom lens is taking us even deeper in the macroscopic world of ULD
- We need to be able to select sub domains in which we can meet the challenge and actually reach our basic mission

The Disabled Population in the Educational System

- Remember one of our basic goals is to:
  - Create a set of principles (and / or tools) for curriculum development that give "all" individuals access to opportunities to learn
- If our efforts work well in the micro world, we should be able to integrate our product into the next higher macro world
- For our micro world we will look into mathematics (actually arithmetic) and the severely vision impaired.

Why Math?

- Actually we will start with arithmetic.
- This domain of education is one of the most challenging in the educational world
- For blind students, math is too often a dead end
- Failure in arithmetic leads to failure in higher math, which restricts blind students from careers in STEM disciplines

Starting Early

- The longer we wait to educate students with visual impairments, the better the chance that we will have a lower level of success.
- Failure at this level is exacerbated by two other issues.
- These two issues have been documented in the U.S. education system – especially true in math and science

Starting Early

- In the US and many other countries we don't have teachers
  - That are well versed in teaching arithmetic, math and science to any group
  - That are familiar with tools and methods in their teaching domain - namely visually impaired students.
- Many parents are also not equipped to do this job
- To achieve best results, we need tools that serve all three members of the teaching/learning team which includes

Starting Early

  - Students
  - Teachers
  - Parents
- Mainlining has mandated this approach
- Special schools, with advanced teaching skills, are disappearing
- The result is clear: we need to develop a tool that will help young (sighted and blind) students learn arithmetic and beyond

Now for a Case-in-Point

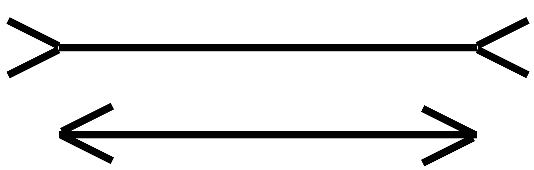
- The case we will analyze is called the AutOMathic Blocks project
- Designed primarily to help young blind students in their effort to learn arithmetic.
- The general principle is based on the assumption (hypothesis) that math is more easily learned when manipulated in a two dimensional space

Now for a Case-in-Point

- We have run numerous usability studies that affirm this hypothesis
- The hypothesis stems from a famous , and well known illusion concerning the length of straight lines

Now for a Case-in-Point

- The Müller-Lyer Illusion
  - Visual presentation
  - Tactile presentation



Now for a Case-in-Point

- Another interesting finding is in the domain of tactile input and the effects on reading Braille by blind/dyslectic students
- This along with the Muller-Lyer illusion, hints at the general concept of tactile input and connection with the visual cortex (or equivalent) area of the brain.

Now for a Case-in-Point

- The results tend to indicate that multidimensional information can be transferred via touch as well as vision
- The systems we will examine uses this this premise as its key feature
- **Bottom line**: we will be able to give visually impaired students a two dimensional view of arithmetic and math

Case-in-Point

- Traditional Braille-like systems only offer a single dimensional view of math.
- Any “second dimensional” view of math is achieved through special codes that help the student in building a two dimensional mental model from a one dimensional presentation tool

Case-in-Point

The Equation	$c = \sqrt{a^2 + b^2}$
MathML Representation	<mrow> <mi>c</mi><mo>=</mo><msqrt> <mrow> <msup> <mi>a</mi> <mn>2</mn> </msup> <mo>+</mo><msup> <mi>b</mi> <mn>2</mn> </msup> </mrow> </msqrt> </mrow>
LaTeX Representation	\[c = \sqrt {{a^2} + {b^2}} \]
Nemeth Representation	c .k >a^2"+b^2"]

Case-in-Point

- On a much simpler level, the problem shown in the slide above is also a problem in simple arithmetic.

1234 + 899

versus

```
   1234
+   899
```

Case-in-Point

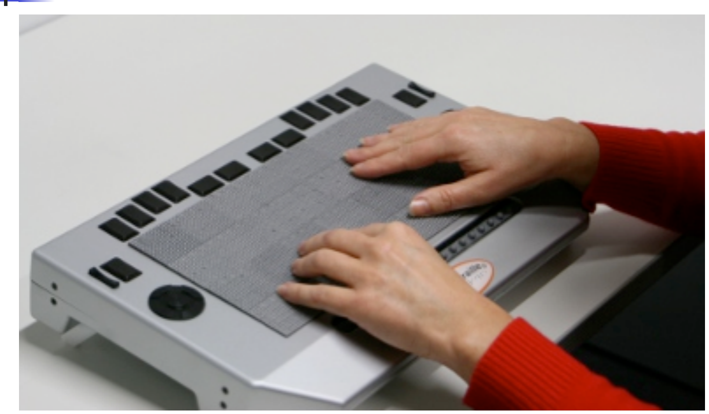
- Our initial usability studies clearly indicated that young blind students
  - Regularly reduced their problem solving time by an average factor of two (half the time)
  - Reduced their error rates by similar percentages
  - None of our subjects had ever used the system before their participation in the study
  - These findings should improve with practice

Case-in-Point

Case-in-Point

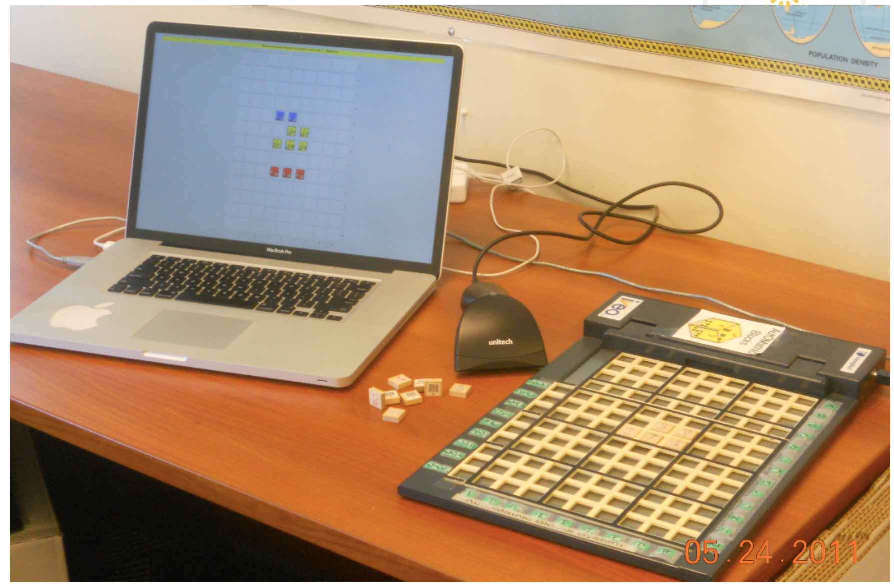
- Refreshable Braille devices, on the other hand, are basically single dimensional
- Refreshable multi-dimensional Braille devices are becoming available, but at VERY high prices
- The HyperBraille system with a resolution of 120x60 refreshable dots costs in the tens-of-thousands of Euros

The HyperBraille System



Case-in-Point

- The AutOMathic Blocks system supports 117 traditional Braille characters on 2.54cm x 2.54cm blocks.
- Small grid compared to HyperBraille, but more than adequate in learning arithmetic, and, at a cost of 200 dollars
- The system uses Braille tagged blocks that are placed on the workspace

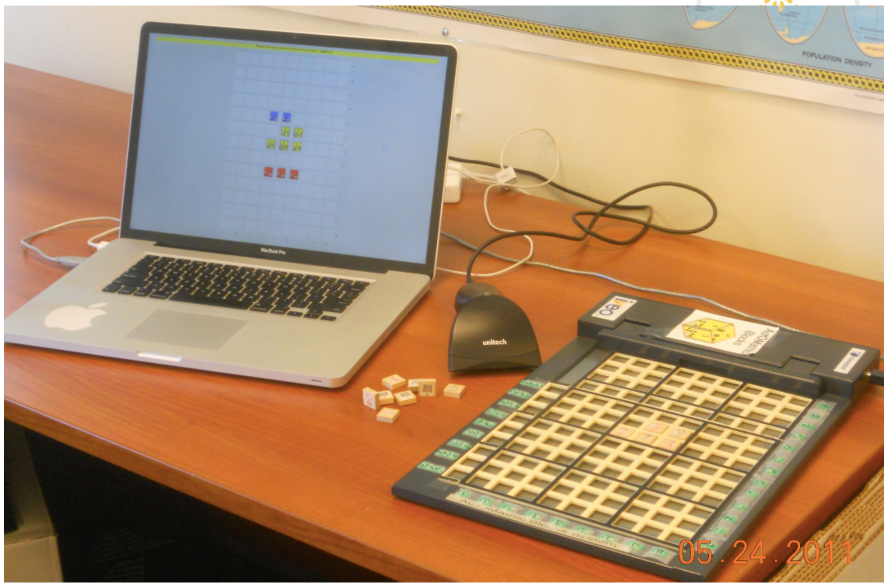


Case-in-Point

- In this system, learning problems can be laid out in two dimensions, allowing the student to use his/her finger to scan the exercise as a sighted person would see it
- In a recent study (as reported above) of blind students solving problems in 2-dimensions showed that the 2-D presentation decreased solution time by a factor of two

Case-in-Point

- The student is monitored and tutoring is always available from
  - The attached computer – speech output in virtually any spoken language (table driven)
  - The observing teacher
  - The observing parent
- The computer also presents an image of the student’s work with extra information to help the teacher or parent



Case-in-Point

- Expanding student's knowledge of math Braille codes – a skill probably needed later in learning process
  - System can convert the 2-D representation into literary or math braille presenting it on a standard refreshable Braille device
  - Again working with electronic or human tutoring

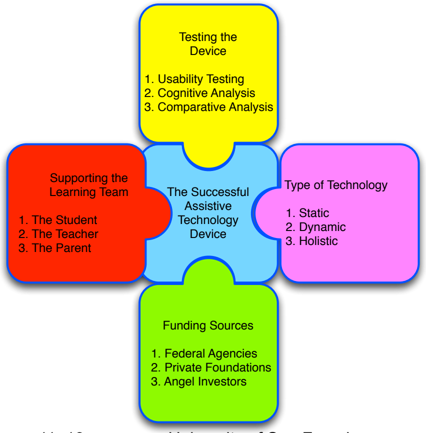
Case-in-Point

- Learning basic grammar and spelling
  - There is no reason why the blocks can't contain letters rather than numbers
  - Teaching basic grammar rules can be used for interactively writing, reading and correcting literary material
  - The same is true for spelling
  - The domain of possible uses is broad

Other Guidelines for Building Assistive Tech.

- Assistive technologies are important tools to make the learning experience accessible to "all"
- While more implementation oriented, these factors can make a device a useful tool in the teaching toolbox
- Briefly these factors are:

Other Guidelines for Building Assistive Tech.



Supporting the Learning Team

- The student – well, obvious!
- The teacher
  - Often does not know how to use the technologies
  - System suppies tools to help the teacher
- The parent probably needs more support than required by the teacher
- Keep in mind that all of these three groups are important players in this process

Testing the Device

- Absolutely essential
  - Usability testing
    - Is your basic hypothesis correct
    - If not, totally rethink what you are doing
    - Use the appropriate subjects
  - Cognitive Analysis
    - If your project involves basic understanding of mental processes, you will need to do this
    - Find a cognitive psychologist to help

Testing the Device

- Comparative analysis
  - Is your technology actually better than other similar devices available on the market
  - Exact analysis in this domain is difficult as no two technologies are alike
  - Here is a good place for usability testing
  - Perhaps price differential might be a good metric

Type of Technology

- The type or functionality is an important factor in building, and using an assistive technology
  - Static devices
    - Translates math content into a form usable by other functional units such as
      - Refreshable displays
      - Embossing printers
      - High resolution pin displays
      - Not much more than a page of a book

Type of Technology

- Dynamic Devices
  - Similar to static devices with important differences
    - Mathematical content can be sent to a device that aids the user in the understanding of the content
    - The device helps uncover the innermost structure of the equations
  - Effectively an equation browser

Type of Technology

- Holistic Devices
  - Can do all of the above devices plus
  - User interaction with the device
  - Modify the equation / problem being presented
  - Test and tutoring concerning user changes and/or solutions

Funding Sources

- Nothing need be said here

Conclusions

- If interface able with another tool, make sure that the connectivity is also consistent with ULD principles
- The device we defined and specified is a reasonable first step in building a ULD consistent device
- The act of building a tool to support our principles is an exhaustive effort

Conclusions

- ULD principles require an interdisciplinary effort whether the product is a learning tool or a new curriculum
- Also, keep in mind that ULD principles are used in project design, and absolute adherence is rarely possible

Questions and comments Please