

# K-12, Multiple Representations of the Same Objects: A UDL Pathway to Accessible Educational Materials

Leslie Siegel, Ed.S.  
Wellington, Florida, USA  
stringmath@comcast.net

## Abstract

*The explosion of Accessible Educational Materials (AEM) made possible by technologies, materials and manipulatives creates a UDL pathway to using multiple representations of the same object to meet the needs of varying student populations, learning styles and preferences for different attributes; possibly at the same time. Educators have become aware that they can cross over exceptionalities to use materials, manipulatives and technologies to meet the needs of general education, special education, gifted, sighted and visually impaired students, etc. In this paper, a modified version of Jerome Bruner's mathematical Concrete to Abstract theory, is used as a mnemonic device to provide an organizational structure for a variety of science materials. This concrete-pictorial-abstract (CPA) model can be generalized to other subject areas.*

## Keywords

UDL, Multiple Representations of Materials and Technologies, Concrete-Pictorial-Abstract, Accessible Educational Materials (AEM,) General Education, Special Education

## INTRODUCTION

The changes in today's general education and special education classrooms keep coming at a fast pace, and inclusion is more prevalent than ever. Teachers must accommodate a wider range of student abilities, often with varying classifications.

Providentially, there is a tremendous explosion of new technologies, materials and manipulatives. These advances have made it possible to have multiple representations of the same object, to address the needs of varying student populations (frequently with the same materials and technologies), and to match the lesson experiences to students' broad learning styles.

Choosing which materials and technologies to use can be overwhelming to educators. Myriads of material and technology choices stored on school shelves and rolling carts often have a lack of unity or pattern even when listed alphabetically and/or by type.

A revised grouping of these items by a recognized, educational theory is needed

The organizational structure of Jerome Bruner's Concrete-Pictorial-Abstract (CPA) theory has the inherent structure to address this issue, and more. This sequence can be applied to different subject areas, including science. Additionally, the model can be modified to include today's modern technologies and materials simply by redefining the concrete section and adding graduated steps within the pictorial section.

Teachers are very familiar with this model which has appeared in math textbooks for years. As such, application of the model to science and/or other subject areas with expanded options can be seamless.

Most importantly, the modernized version of the CPA model is non-static, fluid and able to expand to accommodate future inventions, technologies and materials.

## UDL AND CPA LEARNING THEORY

Bruner's model does not formally address the use of technology, assistive technology, new materials and/or manipulative options for various student populations (students with disabilities including visual impairment-including blindness, orthopedic impairment, hearing impairment, deafness, deaf-blindness, intellectual disability, specific learning disability, autism, giftedness, etc.). That daunting task has been delegated to educators, who have been left to their own devices.

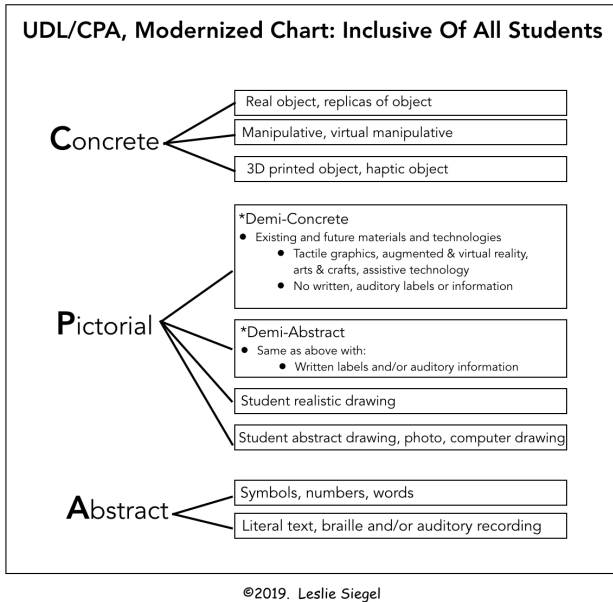
The updated CPA model enables all students, including those with disabilities, to experience multiple means of engagement, multiple means of action and multiple means of expression via a range of materials and technologies. This introduces a Universal Design element to the components within the model.

As stated in the Universal Design for Learning (UDL) framework, flexibility (in this case, of materials and technology) is key because it allows educators to accommodate their students' natural variability in learning preferences.

## ORGANIZING MATERIALS AND TECHNOLOGIES

The material and technology categories are displayed below in multiple CPA chart formats to convey the information in


different ways. During the presentation, multiple representations of lungs, eyeballs and Rubik's cubes were purposely displayed in a random, non-CPA order at hands-on stations for educators to view, experience and replicate. Next, educators participated in a written exercise to organize the multiple representations of lungs and eyeballs on a chart using the familiar, concrete-to-abstract format. The graphic organizer below provides an image of the many current materials and technologies; a mnemonic for future recall.



**Figure 1 UDL/CPA Modernized Chart**




**UDL GUIDELINES APPLIED TO CPA THEORY**

The following two charts provide a material and a technology, and a science example of the concrete and pictorial levels with corresponding UDL Learning Guidelines.

Concrete	UDL Learning Guidelines
<p><b>Basic Concrete Level</b> Real and/or close replica of the item being represented; static, complete.</p> <p>•Real leaf</p> <p>•Commercially produced, realistic replica of a leaf (leaf manipulative)</p> <p>•3D technology, machine produced/printed leaf</p> <p>•Virtual manipulative-computer generated model of concrete object (leaf) which can be manipulated (moved, flipped, turned, etc.)</p> 	<p>UDL Guideline 1: Options for Perception 1.5 Offer ways of customizing the display of information.</p> <p>UDL Guideline 3: Options for Comprehension 3.1 Activate or supply background knowledge 3.2 Highlight patterns, critical features, big ideas, relationships 3.4 Maximize transfer and generalization</p> <p>UDL Guideline 4: Options for Physical Action 4.2 Optimize access to tools</p> <p>UDL Guideline 5: Expression &amp; Communication 5.2 Use multiple tools for construction and composition 5.3 Build fluencies with graduated levels of support for practice and performance</p> <p>UDL Guideline 6: Options for Executive Functions 6.2 Optimize access to tools</p> <p>Detailed Examples: UDL Guideline 3: Options for Comprehension: To teach learners how to transform accessible information into useable knowledge.</p> <p>Checkpoint 3.1 Anchor instruction by linking to &amp; activating relevant prior knowledge Pre-teach critical prerequisite concepts through demonstration or models</p> <p>Checkpoint 3.3 Guide information processing, visualization and manipulation Well-designed materials can provide customized and embedded models, scaffolds &amp; feedback to assist learners who have diverse abilities in using those strategies effectively.</p> <p>Checkpoint 3.4 Maximize transfer and generalization Students need multiple representations in order to transfer the information they have to other situations. Supports for memory, generalization &amp; transfer include techniques that are designed to heighten the memorability of the information, as well as those that prompt &amp; guide learners to employ explicit strategies. Examples: Provide explicit, supported opportunities to generalize learning to new situations. Offer opportunities over time to revisit key ideas and images between ideas.</p>

©2018. Leslie Siegel

**Figure 2 UDL Guidelines & CPA Theory: Concrete**

Pictorial/Representational	UDL Learning Guidelines
<p><b>**Demi-Concrete</b>  </p> <ul style="list-style-type: none"> <li>•Tactile graphic (TG) leaf made out of various materials by current processes: Leaf positioned on a field of paper, etc. Leaf made as "cut out" with edges exactly outlining the object and no background field.</li> <li>•Haptic leaf via different technologies (haptic glove, haptic vibrating mouse &amp; software, etc.)</li> <li>•Arts &amp; crafts produced objects with common things like clay, craft paper, pasta, glue, etc.</li> <li>•No written label, description and/or auditory recording.</li> </ul>	<p>UDL Guideline 1: Options for Perception 1.2 Offer alternatives for visual information 1.5 Offer ways of customizing the display of information.</p> <p>UDL Guideline 2: Language &amp; Symbols 2.1 Clarify vocabulary and symbols 2.5. Illustrate through multiple media</p> <p>UDL Guideline 3: Options for Comprehension 3.1 Activate or supply background knowledge 3.2 Highlight patterns, critical features, big ideas, relationships 3.4 Maximize transfer and generalization</p>
<p><b>**Demi-Abstract</b> : · · · · leaf TGV (with voice)</p> <ul style="list-style-type: none"> <li>• Same as Demi-Concrete only WITH written label in literary text, braille, auditory recording and/or combination of the above. <ul style="list-style-type: none"> <li>• Interactive, tactile, audio/speech, visual (ITASV) experiences made possible with available technology.</li> <li>• Example: A TGV leaf (tactile graphic with voice) embedded with a QR-code reading app which allows text within images to be read and voiced by a mobile device such as an iPhone or Android phone.</li> </ul> </li> </ul>	<p>UDL Guideline 4: Options for Physical Action 4.2 Optimize access to tools</p> <p>UDL Guideline 5: Expression &amp; Communication 5.2 Use multiple tools for construction and composition 5.3 Build fluencies with graduated levels of support for practice and performance</p> <p>UDL Guideline 6: Options for Executive Functions 6.2 Optimize access to tools</p> <p>UDL Guideline 7: Options for Recruiting Interest 7.1 Optimize individual choice and autonomy.</p>
<p><b>Semi-Concrete (no label)</b> </p> <p><b>Semi-Abstract (with label)</b></p> <ul style="list-style-type: none"> <li>•Student realistic drawing of a leaf, abstract versions such as tally marks, etc. made with conventional tools. (i.e. crayons, pencil, markers, tactile drawing products for the blind, etc.) and/or computer generated drawing methods.</li> <li>•Photo of a leaf from a printed source or taken by the student using a digital camera or mobile device, any portable, wireless, handheld device such as tablet, phone, etc.</li> </ul> <p>•White board objects, labels, descriptions, etc.</p>	<p>Detailed Example: UDL Guideline 2: Language &amp; Symbol Learners vary in their facility with different forms of representations- both linguistic &amp; non-linguistic. A picture or image that carries meaning for some learners may carry very different meanings for others. Inequalities arise when information is presented to all learners through a single form of representation. An important instructional strategy is to ensure that alternative representations are provided not only for accessibility, but for clarity &amp; comprehension across all learners.</p> <p>Checkpoint 2.5 Make explicit links between information provided in text &amp; accompanying representation of that information in illustrations, diagrams, etc.</p>

©2018. Leslie Siegel

**Figure 3 UDL Guidelines & CPA Theory: Pictorial**

**ACKNOWLEDGEMENTS**

My sincerest appreciation goes to Dr. Douglas Clements, a prolific and widely cited scholar, Professor at the University of Denver, who has served on NCTM's national curriculum and Principles and Standards committees and on President Bush's National Mathematics Advisory Panel. Dr. Clements graciously corresponded with me regarding math learning theory and suggested research articles to read. He reviewed and positively commented on my modified CPA theory for math, stating that it was well planned, consistent with good practice and would be kept in mind when he taught his methods courses. I was honored by this.

In addition, I want to recognize two amazingly talented and creative educators who graciously agreed to co-present with me. A huge "thank-you" is in order to Janet Good (Region 3) and Dr. Tara Jeffs (Region 4.) They are part of the dynamic, Technology & Learning Connections team for the University of South Florida. Such great ideas and UDL/AEM knowledge!

**REFERENCES**

APH- Educational Research. Guidelines for Design of Tactile Graphics <https://www.aph.org/research/guides/Concrete-Representational-Abstract-Instructional-Approach>.  
<http://165.139.150.129/intervention/ConcreteRepresentationalAbstractInstructionalApproach.pdf>

Sarama, Julie & Clements, Douglas. (2016). Physical and Virtual Manipulatives: What Is "Concrete"? 10.1007/978-3-319-32718-1\_4.

Waldrip, Prain, Carolan (2010). Using Multi-Modal Representations to Improve Learning in Junior Secondary Science. [https://tccl.arcc.albany.edu/knilt/images/5/59/Multi-Modal\\_Representations.pdf](https://tccl.arcc.albany.edu/knilt/images/5/59/Multi-Modal_Representations.pdf)