**MULTIPLE MEANS OF REPRESENTATION**

**Learners differ in the ways that they perceive and comprehend information that is presented to them.** For example, those with sensory disabilities (e.g., blindness or deafness); learning disabilities (e.g., dyslexia); language or cultural differences, and so forth may all require different ways of approaching content. Others may simply grasp information quicker or more efficiently through visual or auditory means rather than printed text. Also learning, and transfer of learning, occurs when multiple representations are used, because they allow students to make connections within, as well as between, concepts. In short, **there is not one means of representation that will be optimal for all learners**; providing options for representation is essential

**Perception**

Learning is impossible if information is imperceptible to the learner, and difficult when information is presented in formats that require extraordinary effort or assistance. To reduce barriers to learning, **it is important to ensure that key information is equally perceptible to all learners**by: **1) providing the same information through different modalities**(e.g., through vision, hearing, or touch); **2) providing information in a format that will allow for adjustability by the user** (e.g., text that can be enlarged, sounds that can be amplified). Such multiple representations not only ensure that information is accessible to learners with particular sensory and perceptual disabilities, but also easier to access and comprehend for many others

# *Offer ways of customizing the display of information*

In print materials, the display of information is fixed and permanent. In properly prepared digital materials, the display of the same information is very malleable and customizable. For example, a call-out box of background information may be displayed in a different location, or enlarged, or emphasized by the use of color, or deleted entirely. Such malleability provides options for increasing the perceptual clarity and salience of information for a wide range of learners and adjustments for preferences of others. While these customizations are difficult with print materials, they are commonly available automatically in digital materials, though it cannot be assumed that because it is digital it is accessible as many digital materials are equally inaccessible. Educators and learners should work together to attain the best match of features to learning needs.

* Display information in a flexible format so that the following perceptual features can be varied:
  + The size of text, images, graphs, tables, or other visual content
  + The contrast between background and text or image
  + The color used for information or emphasis
  + The volume or rate of speech or sound
  + The speed or timing of video, animation, sound, simulations, etc.
  + The layout of visual or other elements
  + The font used for print materials

# *Offer alternatives for auditory information*

Sound is a particularly effective way to convey the impact of information, which is why sound design is so important in movies and why the human voice is particularly effective for conveying emotion and significance. However, information conveyed solely through sound is not equally accessible to all learners and is especially inaccessible for learners with hearing disabilities, for learners who need more time to process information, or for learners who have memory difficulties.In addition, listening itself is a complex strategic skill that must be learned. To ensure that all learners have access to learning, options should be available for any information, including emphasis, presented aurally.

* Use text equivalents in the form of captions or automated speech-to-text (voice recognition) for spoken language
* Provide visual diagrams, charts, notations of music or sound
* Provide written transcripts for videos or auditory clips
* Provide American Sign Language (ASL) for spoken English
* Use visual analogues to represent emphasis and prosody (e.g., emoticons, symbols, or images)
* Provide visual or tactile (e.g., vibrations) equivalents for sound effects or alerts
* Provide visual and/or emotional description for musical interpretation

# *Offer alternatives for visual information*

Images, graphics, animations, video, or text are often the optimal way to present information, especially when the information is about the relationships between objects, actions, numbers, or events.  But such visual representations are not equally accessible to all learners, especially learners with visual disabilities or those who are not familiar with the type of graphic being used.Visual information can be quite dense, particularly with visual art, which can have multiple complex meanings and interpretations depending on contextual factors and the viewer’s knowledge base.To ensure that all learners have equal access to information, it is essential to provide non-visual alternatives.

* Provide descriptions (text or spoken) for all images, graphics, video, or animations
* Use touch equivalents (tactile graphics or objects of reference) for key visuals that represent concepts
* Provide physical objects and spatial models to convey perspective or interaction
* Provide auditory cues for key concepts and transitions in visual information

**Text** is a special case of visual information. The transformation from text into audio is among the most easily accomplished methods for increasing accessibility.  The advantage of text over audio is its permanence, but providing text that is easily transformable into audio accomplishes that permanence without sacrificing the advantages of audio.  Digital synthetic text-to-speech is increasingly effective but still disappoints in its ability to carry the valuable information in prosody.

* Follow accessibility standards (NIMAS, DAISY, etc.) when creating digital text
* Allow for a competent aide, partner, or “intervener” to read text aloud
* Provide access to text-to-speech softwar

**Language & Symbols**

# *Clarify vocabulary and symbols*

The semantic elements through which information is presented—the words, symbols, numbers, and icons—are differentially accessible to learners with varying backgrounds, languages, and lexical knowledge. To ensure accessibility for all, key vocabulary, labels, icons, and symbols should be linked to, or associated with, alternate representations of their meaning (e.g., an embedded glossary or definition, a graphic equivalent, a chart or map). Idioms, archaic expressions, culturally exclusive phrases, and slang, should be translated.

* Pre-teach vocabulary and symbols, especially in ways that promote connection to the learners’ experience and prior knowledge
* Provide graphic symbols with alternative text descriptions
* Highlight how complex terms, expressions, or equations are composed of simpler words or symbols
* Embed support for vocabulary and symbols within the text (e.g., hyperlinks or footnotes to definitions, explanations, illustrations, previous coverage, translations)
* Embed support for unfamiliar references within the text (e.g., domain specific notation, lesser known properties and theorems, idioms, academic language, figurative language, mathematical language, jargon, archaic language, colloquialism, and dialect)

# *Clarify syntax and structure*

Single elements of meaning (like words or numbers) can be combined to make new meanings.Those new meanings, however, depend upon understanding the rules or structures (like syntax in a sentence or the properties of equations) of how those elements are combined. When the syntax of a sentence or the structure of a graphical representation is not obvious or familiar to learners, comprehension suffers. To ensure that all learners have equal access to information, provide alternative representations that clarify, or make more explicit, the syntactic or structural relationships between elements of meaning.

* Clarify unfamiliar syntax (in language or in math formulas) or underlying structure (in diagrams, graphs, illustrations, extended expositions or narratives) through alternatives that:
  + Highlight structural relations or make them more explicit
  + Make connections to previously learned structures
  + Make relationships between elements explicit (e.g., highlighting the transition words in an essay, links between ideas in a concept map, etc.)

The ability to fluently decode words, numbers or symbols that have been presented in an encoded format (e.g., visual symbols for text, haptic symbols for Braille, algebraic expressions for relationships) takes practice for any learner, but some learners will reach automaticity more quickly than others. Learners need consistent and meaningful exposure to symbols so that they can comprehend and use them effectively. Lack of fluency or automaticity greatly increases the cognitive load of decoding, thereby reducing the capacity for information processing and comprehension. To ensure that all learners have equal access to knowledge, at least when the ability to decode is not the focus of instruction, it is important to provide options that reduce the barriers that decoding raises for learners who are unfamiliar or dysfluent with the symbols.

* Allow the use of Text-to-Speech
* Use automatic voicing with digital mathematical notation (Math ML)
* Use digital text with an accompanying human voice recording (e.g., Daisy Talking Books)
* Allow for flexibility and easy access to multiple representations of notation where appropriate (e.g., formulas, word problems, graphs)
* Offer clarification of notation through lists of key terms

# *Support decoding of text, mathematical notation, and symbols*

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# *Promote understanding across languages*

The language of curricular materials is usually monolingual, but often the learners in the classroom are not, so the promotion of cross-linguistic understanding is especially important. For new learners of the dominant language (e.g., English in American schools) or for learners of academic language (the dominate discourse in school), the accessibility of information is greatly reduced when no linguistic alternatives are available. Providing alternatives, especially for key information or vocabulary is an important aspect of accessibility.

* Make all key information in the dominant language (e.g., English) also available in first languages (e.g., Spanish) for learners with limited-English proficiency and in ASL for learners who are deaf
* Link key vocabulary words to definitions and pronunciations in both dominant and heritage languages
* Define domain-specific vocabulary (e.g., “map key” in social studies) using both domain-specific and common terms
* Provide electronic translation tools or links to multilingual glossaries on the web
* Embed visual, non-linguistic supports for vocabulary clarification (pictures, videos, etc)

# *Illustrate through multiple media*

Classroom materials are often dominated by information in text. But text is a weak format for presenting many concepts and for explicating most processes. Furthermore, text is a particularly weak form of presentation for learners who have text- or language-related disabilities. Providing alternatives—especially illustrations, simulations, images or interactive graphics—can make the information in text more comprehensible for any learner and accessible for some who would find it completely inaccessible in text.

* Present key concepts in one form of symbolic representation (e.g., an expository text or a math equation) with an alternative form (e.g., an illustration, dance/movement, diagram, table, model, video, comic strip, storyboard, photograph, animation, physical or virtual manipulative)
* Make explicit links between information provided in texts and any accompanying representation of that information in illustrations, equations, charts, or diagrams

**Comprehension**

The purpose of education is not to make information accessible, but rather to teach learners how to transform accessible information into useable knowledge. Decades of cognitive science research have demonstrated that the capability to transform accessible information into useable knowledge is not a passive process but an active one. **Constructing useable knowledge, knowledge that is accessible for future decision-making, depends not upon merely perceiving information, but upon active “information processing skills”** like selective attending, integrating new information with prior knowledge, strategic categorization, and active memorization. Individuals differ greatly in their skills in information processing and in their access to prior knowledge through which they can assimilate new information. **Proper design and presentation of information**—the responsibility of any curriculum or instructional methodology—**can provide the scaffolds necessary to ensure that all learners have access to knowledge**

# *Activate or supply background knowledge*

Information is more accessible and likely to be assimilated by learners when it is presented in a way that primes, activates, or provides any pre-requisite knowledge. Barriers and inequities exist when some learners lack the background knowledge that is critical to assimilating or using new information. However, there are also barriers for learners who have the necessary background knowledge, but might not know it is relevant. Those barriers can be reduced when options are available that supply or activate relevant prior knowledge, or link to the pre-requisite information elsewhere.

* Anchor instruction by linking to and activating relevant prior knowledge (e.g., using visual imagery, concept anchoring, or concept mastery routines)
* Use advanced organizers (e.g., KWL methods, concept maps)
* Pre-teach critical prerequisite concepts through demonstration or models
* Bridge concepts with relevant analogies and metaphors
* Make explicit cross-curricular connections (e.g., teaching literacy strategies in the social studies classroom)

# *Highlight patterns, critical features, big ideas, and relationships*

One of the big differences between experts and novices in any domain is the facility with which they distinguish what is critical from what is unimportant or irrelevant. Since experts quickly recognize the most important features in information, they allocate their time efficiently, quickly identifying what is valuable and finding the right “hooks” with which to assimilate the most valuable information into existing knowledge. As a consequence, one of the most effective ways to make information more accessible is to provide explicit cues or prompts that assist individuals in attending to those features that matter most while avoiding those that matter least.

* Highlight or emphasize key elements in text, graphics, diagrams, formulas
* Use outlines, graphic organizers, unit organizer routines, concept organizer routines, and concept mastery routines to emphasize key ideas and relationships
* Use multiple examples and non-examples to emphasize critical features
* Use cues and prompts to draw attention to critical features
* Highlight previously learned skills that can be used to solve unfamiliar problem

# *Guide information processing and visualization*

Successful transformation of information into useable knowledge often requires the application of mental strategies and skills for “processing” information. These cognitive, or meta-cognitive, strategies involve the selection and manipulation of information so that it can be better summarized, categorized, prioritized, contextualized and remembered. While some learners in any classroom may have a full repertoire of these strategies, along with the knowledge of when to apply them, most learners do not. Well-designed materials can provide customized and embedded models, scaffolds, and feedback to assist learners who have very diverse abilities in using those strategies effectively.

* Give explicit prompts for each step in a sequential process
* Provide options for organizational methods and approaches (tables and algorithms for processing mathematical operations)
* Provide interactive models that guide exploration and new understandings
* Introduce graduated scaffolds that support information processing strategies
* Provide multiple entry points to a lesson and optional pathways through content (e.g., exploring big ideas through dramatic works, arts and literature, film and media)
* “Chunk” information into smaller elements
* Progressively release information (e.g., sequential highlighting)
* Remove unnecessary distractions unless they are essential to the instructional goal

# *Maximize transfer and generalization*

All learners need to be able to generalize and transfer their learning to new contexts. Students vary in the amount of scaffolding they need for memory and transfer in order to improve their ability to access their prior learning. Of course, all learners can benefit from assistance in how to transfer the information they have to other situations, as learning is not about individual facts in isolation, and students need multiple representations for this to occur. Without this support and the use of multiple representations, information might be learned, but is inaccessible in new situations.Supports for memory, generalization, and transfer include techniques that are designed to heighten the memorability of the information, as well as those that prompt and guide learners to employ explicit strategies.

* Provide checklists, organizers, sticky notes, electronic reminders
* Prompt the use of mnemonic strategies and devices (e.g., visual imagery, paraphrasing strategies, method of loci, etc.)
* Incorporate explicit opportunities for review and practice
* Provide templates, graphic organizers, concept maps to support note-taking
* Provide scaffolds that connect new information to prior knowledge (e.g., word webs, half-full concept maps)
* Embed new ideas in familiar ideas and contexts (e.g., use of analogy, metaphor, drama, music, film, etc.)
* Provide explicit, supported opportunities to generalize learning to new situations (e.g., different types of problems that can be solved with linear equations, using physics principles to build a playground)
* Offer opportunities over time to revisit key ideas and linkages between ideas