How Intellectual Disabilities Can Change Education

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Abstract
Universal accessibility has made significant progress, except in the cognitive dimension. Factors of obstacle to the realization of cognitive activity are unknown. To get to identify them, we observed people with intellectual disabilities in situations of failure in cognitive activities. Ergonomic analysis of these situations shows that the complexity of prescribed tasks is a major factor of obstacle to the realization of cognitive activities. Of the five sources of complexity identified, instability is the most common, the most important and the most difficult to remove. Present in various facets, instability parasitizes our cultural tools, both old and recent. This discovery could change education for all or, at least, improve interventions for students who are experiencing severe difficulties.

1. Problem
According to the International Classification of Functioning (WHO, 2001), environmental factors, in interaction with a person's impairments or disabilities, may become obstacles to the realization of an activity. This model has been successfully applied to identify and eliminate barriers in the motor, visual and auditory dimensions of universal accessibility. But such progress has been slow to extend to the cognitive dimension. In fact, the environmental elements that can become obstacles in this dimension have not yet been identified, which is particularly problematic for education because of the importance and frequency of cognitive activities offered to students. We only know that cognitive limitations are the most neglected in universal design (Chalghoumi, 2011; Adams, 2007; UNO, 1995). At best, a "simple and intuitive use" is prescribed without further specification (W3C, 2008).

2. Method
To get to identify specific barriers to cognitive activities, we used a strategy of universal design, which to ensure accessibility for all (target population), uses a "reference group" composed of individuals particularly sensitive to environmental barriers (Steinfeld and Maisel, 2012). For example, people in wheelchairs are often approached as a reference group for the motor dimension of accessibility. Following the same reasoning, we selected students and citizens who have intellectual disabilities as a reference group for the cognitive dimension. There are usually two ways to identify factors of obstacle in the environment. The first is to ask people who have disabilities what kind of obstacles they face in their environment. The second way is to simulate disabilities. For example, if you want to identify architectural barriers faced by people with motor disabilities, simply move in a wheelchair. The problem with intellectual disabilities is that they are difficult to simulate and that the persons concerned have difficulty to analyze their environment. To circumvent these problems, we systematically observed these people when they were in a situation of failure by using the ergonomic analysis. Ergonomics distinguishes the *task* (what to do), the *activity* (how to perform the task) and the *prescribed task*, that is to say everything that is proposed or imposed on the person for perform the task: the material provided, the instructions, the procedures to follow, etc. (Leplat, 1997).

3. Results
The data collected in 120 situations indicate that the complexity of prescribed tasks is a major factor of obstacle to the realization of cognitive activities. To better understand this phenomenon, we used the technique of "persona" (Nielsen, 2004; Olsen , 2004). It is a fictional character who is assigned the characteristics of a particular group. A persona with the characteristics associated with intellectual disabilities has been systematically confronted with the prescribed tasks observed. This confrontation has identified to date five sources of complexity:

- A high level structure of thought required by the prescribed task. Taxonomies in the cognitive domain are useful to analyze and eliminate this source of complexity.
- A difference between what is explicitly presented to the person and what the person needs to understand. For example, the need to make an inference. It is generally easy to avoid this source of complexity by a more explicit presentation of information.
- The number and order of procedures. This source of complexity can be reduced by providing facilitators such as a list with numbers, illustrations, etc.
- Special cognitive demands (specialized vocabulary, technical expertise, bilingualism, etc.). These requirements are easy to spot and can usually be avoided.
- The instability of cognitive elements of the prescribed task. We consider unstable an element of the environment if it is changing, inconstant. Instability poses very different problems.

The instability is the source of complexity which proved to be the most frequent and most important because of its many facets. We found 41 facets of instability so far:

1) cardinal instability, 2) instability of grammatical agreement, 3) of classification, 4) of digital base, 5) of code 6) of conjugation, 7) of color, 8) of designation, 9) of size 10) of shape, 11) of formulation, 12) of language, 13) of readability 14) of logo or pictogram, 15) of the plural, 16) of pattern, 17) of location, 18) of numbering, 19) of the plane in space 20) character font, 21) of the presence, 22) of procedure, 23) of pronunciation, 24) in proportion, 25) of rule 26) of style, 27) of system, 28) of size 29) of expression, 30) in importance or relevance, 31) in intelligibility, 32) of orientation, 33) of the time course, 34) of uniform, 35) of unit measurement, 36) of the number of dimensions, 37) of verb tenses, 38) instability between oral language and written language, 39) ordinal instability, 40) semantic instability, 41) symbolic instability.

To these 41, add the multifaceted instability which can be observed on the same element of the environment. For example, the size and number of coins are unstable indicators of their value. The value equivalency between two 5 ¢ and one 10 ¢ means admitting that 2 large coins are equal to 1 small coin.

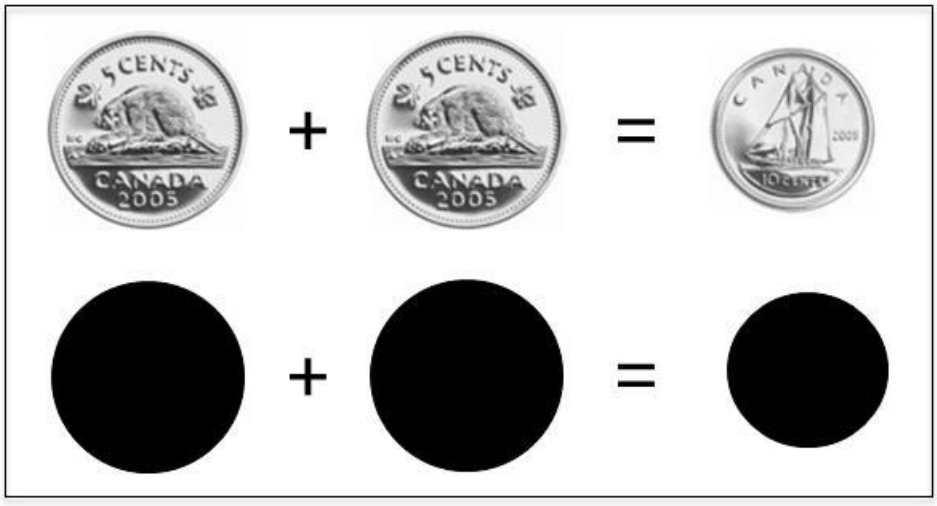

Fig.1 Two large = one small?

Who remembers that originally this equivalence was based on the amount of nickel (2 x 5 ¢) required to match the value of a lesser amount of silver (10 cents)? Although these metals have long been replaced by less expensive alloys, appearances were kept instead of adopting a more logical system.
The instability is the source of complexity that is the most difficult to eliminate. Several cultural tools involved in cognitive activities have a distant past and are so firmly entrenched in our society that it is virtually impossible to eliminate instability without significant reforms.

3.1 Instability of shape (facet # 10)

Consider the simple example of the shape of uppercase and lowercase letters. *A priori,* a capital letter is an enlargement of its corresponding lowercase. But this is true for only 9 of 26 letters (cC , kK , oO , pP , sS , vV , wW , xX , zZ). There are 7 other that are alike but not quite identical (fF , ii, jj , mM, tT uU , yY), while the remaining 10 are really different forms (aA , bB , dD , eE , gG , hH , IL , nN , qQ , rR) . In addition, the choice of font (eg aa) and differences between print writing and handwriting can increase the instability of the shape of the letters. Why expose young children to so many different shapes? Yet we know that many students have difficulty learning a form for each letter. All the children would benefit of more stability of the shape of the letters during their introduction to written communication.

Complexity and, in particular, instability are factors of obstacle not only for people with intellectual disabilities. They can be harmful to all. We will demonstrate it using three examples: system instability in the sequence of numbers, unstable code in the spelling of the French language and multifaceted instability in the digital world.

3.2 System instability (facet # 27)

In French as in English the name of the numbers is determined by a stable system of zero to ten and beyond ninety-nine where adding new names is rare (hundred, thousand, million, billion) because the system uses a combination of known number for each new names. E.g. 9910 says "nine-thousand-nine hundred and ten". But this system is unstable between ten and one hundred. Why "eleven" and not "ten and one"? Why "twenty" and not "two ten" like "two hundred" or "two thousand"? It would be much easier for all children to learn the sequence of numbers without this unnecessary complexity.

3.3 Instability of code (facet # 5)

Humans are particularly conservative in the spelling of their language. In French, for example, traces of the etymology of words and writing rules more o less stable have been preserved. This results in a code which is characterized by extreme instability. For example, there are 150 correspondences between graphemes (letter or group of letters) and phonemes. For the phoneme [o] there is 17 possible graphemes:

au, ault, aut, aux, eau, eault, eaux, hau, haut, heau, ho, o, oc, oh, op, os, ot

Another aspect of the instability, several written letters are silent, which makes the code quite confusing as in the following example where we grayed silent letters:

«Ces nouveaux véhicules utilisent une énergie hybride»

3.4 Instability in the digital world

The monetary system, the shape of the letters, the sequence of numbers and spelling were adopted at times when the desire for universal accessibility did not exist. But there is a whole new area of cognitive activities where instability could be avoid. This is the digital world that is characterized by such instability that users must constantly "relearn". For example, one version to another of the same software, the tools can change of designation, logo, location, appearance, procedure, etc., without gain in utility or usability.

4. Discussion

According to the data analysis, the complexity of prescribed tasks is a major factor of obstacle in cognitive activities. Among the five identified sources of complexity, instability has proved to be the most frequent and the most important. Instability is also the source of complexity the most difficult to eliminate. Several cultural tools involved in cognitive activities are so firmly entrenched in our society that it is virtually impossible to eliminate instability without significant reforms. But the costs of school failure may convince our societies to achieve such reforms. With over 50% of the population which does not reach the third level of literacy and a digital world where instability abounds, it is permissible to think seriously about the need for reforms. Nevertheless, it is certain that the elimination of instability in the realization of cognitive activities is a promising working hypothesis in education. In the design of educational products, stability could be used in

universal design as a facilitator of learning. More specialized applications could be beneficial for students with intellectual disabilities or major learning difficulties.

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