Education and Training | Dr Juan Cristóbal Castro-Alonso

Gender and visuospatial processing in multimedia STEM learning

As multimedia and video are getting cheaper to produce, they are becoming more popular as tools for classroom instruction. With increasing access to digital technologies around the world, teachers, commissioners and policy makers are being encouraged to use more static and dynamic visuals in their lessons even though there is no unequivocal evidence to support this approach. Dr Juan Cristóbal Castro-Alonso is an educational psychology researcher at Universidad de Chile focused on better understanding whether the use of multimedia makes learning science more efficient and—if so—under what circumstances.

Cognitive resources are limited

Dr Castro-Alonso and his collaborators in Australia and the Netherlands have previously noted that different types of instructional materials might be better at supporting the learning of different types of tasks. They have argued that these differences are related to the functioning of specific neural systems that underpin the acquisition of particular skills, and are also mediated by the amount of mental resources required to process the specific multimedia materials.

For example, with dynamic materials like videos or animations, the learner must often process more information due to the transient nature of dynamic presentations. Despite this concern, dynamic materials appear to be better at supporting manipulative tasks, i.e. tasks that require physical action (like replicating an origami model). In contrast, static images seem more effective at supporting learning for non-manipulative tasks, i.e. tasks that are more cognitive than physical (like solving abstract symbol problems).

This difference can be explained by cognitive load theory, which proposes that a learner has a limited amount of cognitive resources (working memory) and any loss of this capacity to tasks that do not directly support learning or require more processing is detrimental to the overall learning effectiveness. If more cognitive resources are spent on processing teaching materials, there is often not enough left over to efficiently complete the task at hand.

Mirror neurons to the rescue

Within an evolutionary approach to cognitive load theory, it has been suggested that dynamic images might be able to well-support learning tasks that require movement because manipulative tasks evolved as a primary skill in humans and are therefore likely processed by a separate system (for example, mirror neurons). This specialised circuit allows learning of manipulative skills from visual images without exerting extra effort. In contrast, learning a non-manipulative skill from a moving image requires effort to remember the information before attempting the task. As such, by the time the student attempts the task, processing learning materials has already diminished their cognitive resources. In this case, the use of dynamic multimedia may hinder rather than support student performance.

But not so fast

A plausible theoretical framework notwithstanding, Dr Castro-Alonso points out that the data on learning from visuals is complex and difficult to interpret with any degree of certainty. First, it remains unclear whether differences between learning efficacy from static versus dynamic images in fact exist. Studies that report these differences often neglect to control for many potentially moderating variables that relate to the materials themselves. Some of these factors are appeal, media, realism, size, and interaction. Second, participant-related variables—including gender, spatial abilities or attained level of education—remain unexplored. In a recently published meta-analysis, Dr Castro-Alonso and colleagues aimed to examine whether differences in learning efficacy between static versus dynamic visuals indeed exist when studies are pooled together; they also looked to identify the factors that affect any existing differences.

A meta-analysis is a type of study that compiles all studies that aim to answer a specific question. Studies are selected on pre-specified inclusion and exclusion criteria, and then combined to identify a common effect. Dr Castro-Alonso and colleagues searched for and included studies that reported results of randomised experiments where two groups of students were compared: a group learning from static images and a group learning from dynamic visualisations. Studies were included if they reported measurable outcomes that could be used in statistical analysis and where they included tasks that could

As access to digital technologies increases, teachers are encouraged to use static and dynamic visuals in classrooms—what’s the evidence?
Researchers so far have sometimes failed to report whether studies have been done on males or females.

Dr Juan C. Castro-Alonso’s research uses quantitative randomised controlled experiments to investigate the variables influencing the teaching and learning of STEM topics, with particular focus on integrative teaching methods, including multimedia.

References

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Personal Response

Gender is a variable normally reported in health and psychology research as one of the main moderators of outcomes. Why do you think colleagues in your field have reluctantly reported on effects of gender in their studies? Do you think this is more or less likely to change in the current political climate?

We don’t know why gender is not being considered an important variable in educational multimedia research, or at least important enough to be reported in the investigated groups. We know that this problematic under-report exists, but we don’t know the causes. I have not investigated the political climate, so I’m not sure if the climate is currently trying to equate women and men or acknowledging that there are gender and sexual differences, including the differences that can influence visuospatial processing and STEM multimedia learning.