Applying Grounded-Embodied Cognition to Improve Learning

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Embodied/Grounded Cognition (1)

- Embodied/Grounded Cognition is an increasingly prominent area of basic Cognitive Research and Theory (Barsalou, *Annual Review of Psychology*, 2008)

- Embodied/Grounded Cognition says a full understanding of something involves being able to create a mental perceptual simulation of it

- An example of the evidence is in property verification (Horse-Mane) perceptual variables like size affect verification times and errors (e.g., Barsalou, 2004; Morrison and Tversky, 1997)
Embodied/Grounded Cognition (2)

• Also perceptual areas of brain become active in property verification -- shape, color size, sound, taste, action, touch (e.g., Martin, 2007)

• Get spatial effects in text comprehension (Black, Turner and Bower, 1979) – e.g. switch in POV gives increased time and memory errors
  John was working in the front yard then he went (came) inside.

• Get Motor Simulation Effects in text responses
  John gave the book to Rita
  faster “yes” response if push lever away than toward
  (Glenberg and Kaschack, 2003)

• Get motor areas activated when reading if played a sport, musical instrument or dance (Holt and Beilock, 2006)
Application to Reading Comprehension

- Glenberg (J.EdP, 2004) applied embodied/grounded cognition to teaching reading comprehension
- Found that having 2nd graders manipulate objects (e.g., farm objects) to enact a story lead to better memory for the story
- However, to get facilitation on another story also needed practice imagining moving the objects as described in story
- Thus, direct perceptual experience + imagined perceptual experience seems to be necessary
- Glenberg (Instructional Science, 2011) showed same results with manipulating images of toys on computer screen
Grounded/Embodied Learning

• 1) Provide Full Perceptual Experience of What Learning About (as Full as Possible)
• 2) Activate Prior Relevant Experiences
• 3) Imagine These Experiences While Doing Symbolic Learning
• 4) Transfer to Related Learning
Graphic Simulations as Grounding for Learning

- Interactive Graphic Simulations can ground learning.
- For less capable students and more complex material, need simulations.
- As increase perceptual richness of simulation learning increases and depth of learning increases.
- Grounded simulations can also remind students of relevant prior experiences and doing so increases learning.
Minimal Embodiment: DMA Simulation Studies

• Functional Relations Describe How One Entity Changes as a Function of Change in Another
• Showed Direct Manipulation Animation DMA Good Way to Learn This
• DMA provides minimal embodiment by moving hand to manipulate one variable then seeing animated results of changes in others
• Learning this with simulation most important for less capable students and more complex systems

(Chan and Black, Learning Sciences, 2006)
Roller Coaster Simulation Game
Force Feedback Study

• If further enhance the haptic channel (movement and touch) by adding force feedback get better learning (Han and Black, *Computers and Education*, 2011)

• In gear pair simulation move gears with joystick and add force feedback to joystick increases learning and transfer
Force Feedback Simulation

8-tooth gear x 16-tooth gear combination
Rotate the 8-tooth gear on the left with your joystick.

Input Force | Output Force
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Two way communication between simulation and learners with force feedback joystick
Force Feedback and Experience Priming

• Followup study (Huang, Vea and Black, EdMedia, 2011) used 3D force feedback joystick with catapult simulation
• Found better learning of Newton’s laws of motion and transfer to learning move advanced topic of gravitation
• Best results came when used force feedback to prime prior related experience
3D Joystick
Catapult Simulation (1)
Catapult Simulation (2)

Height is 75
Distance is 300
Weight was 5 kg
Launch angle was 45°
Video Game Experience as Preparation for Future Formal Learning

- There was been a lot of hype about video games as great learning environments no real evidence they are good for learning academic content
- We examined direct learning of content with video games plus using them as an experiential basis for future formal learning (Hammer and Black, *Educational Technology*, 2009)
Questions

• Wanted to look at what each game expert had learned of the game academic content compared to other game experts
• Also wanted to look at whether this game play prepared them better for learning more about the content in formal ways

Preparation for Future Learning
Bransford and Schwartz (2001)
Experience and Education
Dewey (1938)
Video Game Study Method

- Recruited experts in two video games with academic content (Civilization and Sim City) from online discussion forums
- Tested what they knew of history that was in the game
- Pre-tested content of college history book chapter
- Participants read book chapter
- Post-tested on book chapter (facts, procedures, images and mental models)
Results

• Civilization Game Experts showed no initial direct learning from their playing of the game compared to non-experts
• But Civilization Game Experts Showed Better Preparation for Future Learning on all four knowledge types -- greater learning from reading text book chapter
• Thus Civilization provided embodied experience that improved learning from reading a text – sort of like playing with objects did in Glenberg study
Linking Background Reading to Simulation Gaming Experience

• We studied the effect of adding two types of reflective questions to business simulation game (entrepreneurship)

• College business students read background readings, then played game several times: one group just played game, another was asked about strategies, and another about strategies and how they relate to background readings.

• The strategy plus background readings questions led to better learning than the other two conditions

(J. Ahn, eLearning, 2008)
Learning in Virtual Environments (LIVE Project)

• Can use virtual worlds like Second Life and OpenSim to have students embody learning through role playing

• Found that if students act out episode with Moghul Emperor when learning about this historical episode then learn better and transfer to reading literature from era

Moghul Emperor in Second Life
Simulations plus Direct Embodiment

• Compared using Hands-on-Activities (HOA) in classroom alone with adding System Simulation (SS) and Remote Link (RL) to larger real version of HOA
• The study focused on learning about the water chemistry of a fish tank (the class also dealt with the biology of fish and plants)

(McVeigh and Black, SITE, 2008)
Hands-on-Activities plus Simulations

- Compare hands-on-activities with small fish tanks in the classroom with adding interactive graphic simulation with movement
- Adding graphic simulation increased memory somewhat and problem solving a lot
- Adding remote link to large fish tanks at Rutgers Ecoplex did not increase learning (although maybe better design would)
- Adding simulation probably aided ability to imagine and mentally simulate the mental model
Catch a Fish, Weigh a Fish

To weigh a fish, you should "catch" it (by picking it out of the fish tank with the mouse), and drop it into the blue jar of water that sits on the scale. The jar and water together, without any fish in it, weigh 150 g. To find out how much a fish weighs, note the weight of the jar with the fish in it, and subtract 150 g from it.

To put a fish back in the tank, simply click on the fish.

Catch and weigh three different fish and record the results. Compute the average of the three and use that as the basis for determining how much to feed the fish.

(And also in this panel, we could have a workspace, and maybe even a calculator, to help the student keep track of measurements taken and calculations made.)
M3 Project: Mobile, Movement and Math

• Current M3 project developed and tested learning of fractions though gestures on tables and smartphones

• Looking at congruent conceptual gestures (like before) compared to pointing on touch interfaces

• Also looking at effect of narrative to help embody – using story characters and settings from *Cyberchase* TV show
M3 Project
M3 Project
Complicated M3 Results

- Our main prediction was born out: Narrative-Conceptual-Gestures (most embodied) version gave best understanding – transfer test
- However, we also had results that surprised us
- For students who initially had less knowledge the Minimal Non-Narrative-Pointing-Gestures version gave best direct learning
- As the students knowledge increased that switch to direct learning from the Most Embodied Narrative-Conceptual-Gesture version being best
- This suggests as Adaptive approach where we start with Minimal design then move to Embodied design might give best results
- We want to follow-up testing this directly both with content and other content and types of students
- This would be a revision to our Maximal Embodiment Principle