Multimedia learning and cognitive load in children

Considerations for Multimedia Designers and Educators

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Learning Theories

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Introduction

The use of multimedia design is becoming more and more common these days in education. There are many software designers that boast how effective their products are. Although there may be some good instructional designs in place many of the claims come lacking empirical research. The studies that I have reviewed discuss some of things that should be taken into consideration when deciding on a product to use or when designing one that targets children. Most of the research that we have seen to date involves college students or adults but very little research has actually been done in the areas of multimedia learning and its effects of children. The fact is that children learn different than adults and the results or findings from research done with older subjects may not transfer to younger children. A lot of instructional design often targets children and therefore the need to consider the implications of the design is crucial.

ARTICLE	*DESCRIPTION OF SAMPLE*	*VARIABLES, KEY IDEAS, AND OR TECHNOLOGY*	*FINDINGS*
Acha, J.(2009). The effectiveness of multimedia programmes in children's vocabulary learning. *British Journal of Educational Technology*, 40(1), 23-31.	135 Spanish Children (67 female, 68 male) from 3 primary schools in Vizcaya and Guipúzco, Spain (middle to low socioeconomic population from urban zones) 66 in Grade 3 – Mean Age 8 years 69 in Grade 4 – Mean Age 9 years An interactive multimedia story designed for this study. Story consisted of 101 English words presented in one page. For 12 key in the story, children received visual, verbal or both annotations.	Study investigates which presentation mode is more effective for primary school children learning new vocabulary in a second language with a self-paced multimedia program. *"Cognitive load may occur when two types of stimuli that supply the same information are perceived through the same information processing channel." (p. 24)* **Dependant variable**: Number of recalled words in vocabulary test **Between-subjects factor**: Group (Word-only, picture-only, word and picture) **Covariates**: Verbal ability and spatial ability **Tests**: Immediate and delayed posttests (2 weeks later) were given. 8 students dropped from second posttest due to illness.	• 'Word-only' group showed higher percentage of recalled words than 'word and picture' group in both tests • Percentage of recalled words was higher for the 'word-only' group than the 'picture-only' group significantly in immediate posttest and approached significance in delayed test • Performance in 'picture-only' and 'word and picture' very similar • The study found that the 'word-only' group performed better than the 'picture-only' due to the increase in cognitive load necessary to process the picture, and therefore leading to less effective learning • Required cognitive processes must be considered by designers
Anderson, R. (1992). The Instructive Animation: Helping Students Build Connections Between Words and Pictures in Multimedia Learning. *Journal of Educational Psychology*, *84*(4), 444-452.	136 college students attending the University of California, Santa Barbara Students studied an animation depicting the operation of a bicycle tire pump or an automobile braking system. There was a video animation ofthe operation of a bicycle tire, based on a static illustration in The World Book Encyclopedia (1991), an audio narration abstracted from the text of The World Book Encyclopedia (1991), or both, each lasting approximately 30 s. There were 7 groups and 1 control group receiving no instruction. The animation was created with Adobe Illustrator	The goal of this study is to support and extend on prior research on the role of illustrations in text. **Prediction 1:** The control group would perform worse on retention than the treatment groups, which wouldn't differ from one another **Prediction 2:** The concurrent group, the one given words and pictures contiguously in time, would perform better on problem solving than the other groups which wouldn't differ from one another **Experiment 1** compared the problem-solving and verbal retention performance of those receiving concurrent versus successive presentation of animations (A) and narrations (N) of how a pump works 8 Groups: 1. Concurrent (animation with concurrent narration, presented three times) 2. 4 versions of successive (ANANAN, NANANA, AAANNN, NNNAAA) 3. Animation only 4. Narration only 5. No Instruction (Control Group) **Experiment 2** looked to replicate and extend the results of experiment	• **Prediction 1:** Recall scores confirmed that the groups differed significantly from one another and control groups scored significantly lower than each of the other groups and the remaining seven groups did not differ from one another, except that the ANANAN group scored higher than the A A A- only group. In Experiment 2 each of the treatment groups except the AAA-only group scored significantly higher than the control group and none of the treatment groups differed significantly from one another • **Prediction 2:** In both experiments it was found that subjects in the concurrent group produced greater than 50% more creative solutions than any other groups. Test revealed that the concurrent group performed significantly better than all other groups, which did not differ significantly from one another. • **Limitations:** Results may have differed using subjects with more experienced instead of using ones that lacked prior knowledge. Results may be limited to expository passages rather than descriptive or narrative. Overall retention was not measure

	and MacroMind Director and the audio was created with MacRecorder and MacroMind Director.	one using a different topic, how a car breaking system works **Tests:** Following instruction, in which the narration, the animation, or both were presented three times, students took a retention test and a problem-solving test.	(problem-solving transfer and retention were), which would have concluded that there were not many differences between treatment groups. • **Conclusion**: The results demonstrate that animation alone does not necessarily improve understanding, however, when paired with concurrent narration there large improvements in problem-solving transfer. It's hypothesized that contiguity between words and pictures is encourages learners to build connections between their verbal and visual representations and therefore supports problem-solving transfer. The results of the study support the contiguity effect in multimedia learning and may need to be extended from just words and images to include animation as well. ''*Students learn best when the words and pictures of an explanation are presented contiguously in time or space."(p. 450)* •
Large, A., Beheshti, J., Breuleux, A., , & Renaud, A. (1995). Multimedia and comprehension: The relationship among text, animation, and captions. ***Journal of the American Society for Information Science*****, *46*(5), 340 - 347.**	71 Students from three Montreal schools Grade 6 - Median Age 12 "How to find South with Two Sticks" from Compton's Multimedia Encyclopedia on CD-ROM. Students viewed a procedural text that included four-sequence animation with captions on how to find south using the sun's shadow. Students either received text, text plus animation, text plus captions plus animation or captions with animations.	The goal of this study was to determine what multimedia conditions aid in comprehension. **Presentation conditions**: Text (T), Text and animation(TA), Text and animation and captions(TAC), Animation and captions(AC) – 4 Groups **Between-subject factors**: Presentation condition, gender, and school **Within-subject factor**: Type of measure (recall, inference, frame comprehension) **Tests**: immediately after viewing – asked to recall in their own words what they learned and also asked to enact the procedure • Recall scored according to written recall of propositions steps and enactment • Measures: info recalled, and info correctly inferred	• No significant relationship found between recall or enactment and the student's gender or school • The two groups with text and animation (TA &TA& 2C) recalled more procedural than descriptive propositions. • Both TA and TAC performed significantly better than T group(having more difficulty enacting than recall) • The opposite found in the AC group where students were better in enactment than recall • TAC group was strong in both enactment and recall • Recall levels similar for 3 of 4 groups • AC had lowest recall but not statistically significant • TA group performed marginally better at recall and inference (yet similar for the 4 groups) • Recall of procedural propositions highest in TA and TAC groups • AC performed as well on recalling descriptive propositions as 2 of the 3 groups seeing text • **Conclusion:** Literal recall of information may not be enhanced by animation. If the learning objective is to understand the principles underlying a text, animation may help and the addition of captions may slightly improve this understanding. Animation w/o

			text is less effective than animation with text, and short captions do not act as a substitute for a text proper. • **Overall the best scores at both recall and enactment of the main steps was achieved by the group having access to the most info TAC. • If the educational objective is to enhance comprehension rather than mere accurate recall of read material, then multimedia tools should be considered. Texts enhanced with animation sequences seem to facilitate understanding of procedural texts.
Segers, E., Verhoeven, L., , & Hulstijn-Hendrikse, N. (2008). Cognitive processes in children's multimedia text learning. ***Applied Cognitive Psychology*****, *22*(3), 375 - 387.**	128 Children from 5 elementary schools south of the Netherlands (middle-class suburb) All in Grade 5 62 boys 51 girls Mean Age 10 years Lessons on construction and energy from physics book presented in Microsoft PowerPoint. Title page plus 7 text pages received either as oral text only, oral text with pictures, written text only and written text with pictures.	The goal of the study was to look further into the modality and multimedia effects among children. They wanted a realistic setting therefore conducting the study during school hours and rather than using system-paced lessons the study used four learner-paced multimedia lessons. *"The advantage of oral over written presentations expected to be higher for particularly children with lower verbal abilities because the cognitive load of reading a text is greater than the cognitive load of listening to a text for these children." (p. 378)* **Within-subject factors**: Oral Text only (O), Oral text with pictures (OP), written text (W), and written text with pictures (WP) Verbal and spatial intelligence were assessed.	• OP produced better short-term performance than WP but a week later the difference was gone • The multimedia effect (added value of pictures) found only in O but not W (short-term difference between OP and W only showed trend) • For quantity of learning a short-term modality effect was found with O presentations producing better results than the WP. As far as quality of learning, the modality effect was found immediately following intervention independent of the use of pictures but reversed a week later, no evidence of multimedia affect found • Contrary to expectations children in O conditions took more study time and modality effect was replicated immediately following intervention • Contrary to expectations use of pictures did not facilitate learning and recall in O and W conditions (possibly due to use of decorative(suppress) rather than representational(enhance) pictures) •
Verhallen, M. J. A. J., Bus, A. G., , & de Jong, M. T. (2006). The Promise of Multimedia Stories for Kindergarten Children At Risk. ***Journal of Educational Psychology*****, *98*(2), 410-419.**	60 At-Risk Kindergarten Children from 33 classrooms in 7 inner-city schools in The Hague, Netherlands with at least 80% immigrant children from families with low educational levels Age 5 30 boys 30 girls Learning Dutch as a 2nd language	The goal of the research was to determine if multimedia features more of a role in comprehension and language skills than stories with static pictures *"We hypothesize that (spoken) text with static pictures, normally the main source for understanding stories, may not be enough for an emerging comprehension of narratives in groups of young second language learners."*	• Retelling by animated vs static pictures using multivariate ANOVA showed no significant difference so scores were combined *Differences Between Experimental Groups* • No statistical significant differences in age, number of months at school, language proficiency, and intelligence • No significant collection found in the use of ethnic background or gender as an independent variable

	The children were randomly assigned to 4 experimental groups. Each group heard the story of *Winnie the Witch* in 2 control conditions.	**Hypotheses:** (a) experimental groups would score better than the control groups; (b) the multimedia groups would score better than the static groups; (c)four encounters were better than one encounter; (d) As a result of repetition, the multimedia group would have a higher increase in score than the static group. **Design:** (a) format (static images vs. multimedia) (b) frequency of story encounters *Winnie the Witch* – experimenter controlled the mouse *Midnight play* – children controlled mouse Both versions, the multimedia and static, have an identical text, are told in the same voice, and both are presented on a computer screen. **Tests:** Pre and post test given	*Effects on Story Understanding* • story comprehension improved in all experimental conditions but more in the multimedia than in the static conditions and more with repetition *Did Story Understanding Broaden as a Result of Multimedia?* • The multimedia condition improved more as a result of an accumulation of encounters with *Winnie the Witch* *Effects on Linguistic Skills* • Vocabulary increased in the multimedia condition but not in the static condition; **Discussion & Conclusion:** When video, sounds, music, and oral text are combined in the multimedia storybook, children at risk seem to profit more from repeated story experiences than with static pictures. For one thing language skills improved. This study provides strong support to the theory that screen media contribute to children's ability to recall story elements.
Witteman M, J. (2010). The modality effect tested in children in a user-paced multimedia environment. *Journal of Computer Assisted Learning*, *26*(2), 132-142.	80 Children in elementary school in area near Rotterdam of The Netherlands 35 girls 45 boys All in Grade 6 Mean Age 11.8 "The Formation of Lightning" – adapted from work of Mayer (translated) using Microsoft Powerpoint	The goal of this study was to test the modality effect in young children considering the cognitive factors and also examine the long-term effects **Characteristics taken into account:** Preferred mode of presentation Learning eagerness Prior knowledge Visual working memory and auditory working memory Spatial ability General school performance **Between-subject factors**: Representational pictures with speech or representational pictures with text **Testing:** Immediately after intervention, a day after, and a week after. Both Transfer and Retention questions were used. **Hypotheses** 1. *"Children who score higher on learning and cognitive measures also score higher overall on the retention and transfer questions"* 2. Modality effect would be found immediately after 1st intervention for retention but would disappear at 2nd testing and remain gone by 3rd.	• **1st hypothesis** –Correlation analysis showed this general effect for reading comprehension, general school performance, prior knowledge and auditory and visual working memory • **2nd hypothesis** – There was no difference between reading and listening on test 2 and 3 as expected however on test 1 they found a reversed modality effect (contrary to literature found with adults but in line with studies using learner-paced design) • **3rd hypothesis** – Can be confirmed in part, there was a reverse modality effect at the 2nd testing occasion. Children in the reading condition had a higher score at T2 than at T1 • **4th hypothesis** – No interaction effect found between learning and cognitive measures and time or condition **Limitation:** All children were required to type their answers in, researchers are curious as to if administering the test orally would have resulted in better scores amongst students with high auditory skills. There was no way to control whether children studied all material. **Conclusion:** Study found no evidence for modality effect

Conclusion

Although the research done in these articles differed quite a bit, the main idea remains the same. In order to create multimedia instruction there are a number of elements that must be taken into considerations. It is important to consider the needs of students and the type of instruction when designing or purchasing multimedia software. It is also very important to consider the audience. For example, the first study found that the 'word-only' group of children performed better on post tests than the 'picture-only' and 'word and picture'. These results are not consistent with other studies finding words and pictures having better results but the big difference with this study and many others is it deals with children. With children we have to consider smaller working memories and the chance of cognitive overload. Also other factors taken into consideration in the articles were prior knowledge, spatial ability, verbal ability, type of learning was desired and some others. The overall message for designers, educators and parents is to consider the individual needs of the students when deciding what multimedia solution to use or if multimedia instruction is the answer.