The interrelationship between textbook figures and its impact on conceptual understanding

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Introduction

Much research on information graphics (diagrams, illustrations etc) in textbooks has emphasized their usefulness for understanding abstract concepts.[1, 2, 3] However, most existing research has focused on single figures or the relationship between a figure and its accompanying text.[2,3] The relationship between the designs of multiple figures remains unexplored. In this research, we defined two design considerations–visual linking (VL) and hierarchical proximal layout (HPL)–which may be influential when multiple figures exist on a double-page spread. VL is defined as the matching of visual similarities (colors, shapes, etc) with conceptual links between figures. In other words, conceptually related elements (and only these) should also be visually similar. HPL is defined as the spatial layout of figures (proximity, hierarchical positioning, etc) to match the conceptual relationships between them (e.g. related or equivalent constructs; a general class and a specific case). In this study, we hypothesized that enhancing VL and HPL in a multi-figure two-page textbook spread would support the interpretation of conceptual relationships between figures and promote understanding.

Methodology

We undertook a 2 x 2 between groups comparative study with VL and HP as independent variables, and comprehension of content as the dependent variable. Four types of design pages (Original, VL, HPL, and Both) were prepared based on pages from an existing high school biology textbook explaining the cell cycle (See Fig 1). A total of 98 participants were recruited from 1st and 3rd grade students from two participating high schools in the Kanto area. Participants were randomly assigned to one of the experimental pages (Original 27, VL 30, HPL 27, Both 14). After reviewing the materials they were asked to answer a series of questions to evaluate interpretation of the figures and their inter-relationships along with comprehension of the topic. Correct answers scored one point each and the resulting data was analyzed by two-way ANOVA using SPSS.

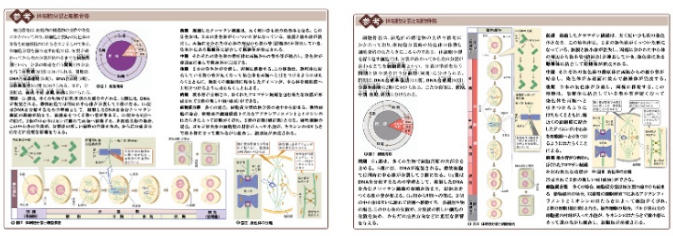

Fig 1. Original (left) and Both (right) version pages.

Result and Discussion

Mean total scores and standard deviations were calculated for each group–Original (M=8.70, SD=2.415); VL (M=7.67, SD=3.337); HPL (M=8.93, SD=2.841); Both (M=8.07, SD=2.165). The two-way ANOVA showed no significant differences for VL ($F(1,94)=2.497$, $p=0.117$), HPL ($F(1,94)=0.274$, $p=0.602$), or the interaction ($F(1,94)=0.023$, $p=0.879$). Therefore it cannot be said that the visual linking or hierarchical proximal layout design modifications in this study influenced the understanding of conceptual relationships between figures. Of course this may be because there is in fact no impact from VL or HPL design interventions. However, due to insufficient statistical power it is not possible to draw reliable conclusions from this data. An a priori calculation for a minimum acceptable power level of 0.8, and with effect sizes (expected to be small in this study) ranging from f=0.2 (medium) to f=0.1 (small), indicates a necessary sample size of between 199 and 787 participants. In this study, societal and logistical restrictions limited the sample size to 98 which yielded statistical power of just 0.17 to 0.50 for an effect size range of f=0.1 to f=0.2. This falls far below an acceptable level (0.80) for statistical certainty. In addition, this study did not account for students' biology background knowledge, which may have been an interacting variable that could have further masked any small effects of design (design changes may be more beneficial for students with mid-level knowledge, rather than those with very high or very low knowledge). A further factor potentially obscuring the effects of the design interventions in the study is the far greater impact of other design and non-design issues. According to qualitative feedback, many participants had difficulties caused by such factors as text font and color, and the amount and complexity of information. This suggests that there may have been fundamental issues such as the design of the text and the amount of content, and this may have had a greater impact on interpretation and comprehension than the VL and HPL design modifications in this study.

Conclusion

To further clarify whether VL and HPL design considerations affect the understanding of conceptual relationships between figures we suggest further investigation should focus on the following three points; increasing the sample size, controlling for prior knowledge, and eliminating other fundamental problems with the page contents.

References

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