Testing the personalisation hypothesis in pre-laboratory e-learning environments

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Introduction

Computer-based multimedia learning environments have been expected to offer a powerful and effective means of improving student learning and understanding (Mayer and Moreno 2002). In recent times, there has been much research activity investigating best practices for design of multimedia instructional materials and for establishing effective e-learning environments. Several principles of design for fostering multimedia learning have been established and tested such as the *multiple representation principle* – it is better to present explanations as words and pictures rather than solely as words and *coherence principle* – people learn better when extraneous words, pictures and sounds are excluded rather than included (Harp and Mayer 1998; Mayer and Moreno 2002).

The personalisation hypothesis

One area of particular interest concerns the personalisation hypothesis. Moreno and Mayer (2000) first asked the question 'Does the use of personalised messages improve students' understanding of a multimedia science lesson?' (p724). They predicted that students who learn from a personalised computer program would remember more factual information and solve problems better than students who learn by means of neutral/non-personalised messages. Mayer and Moreno (2000) conducted two experiments using a short multimedia explanation of how lightning storms develop. Explanations included a 140 second long animation accompanied by personalised speech or text (first person, more conversational style) or non-personalised speech or text (third person, more formal style). The experiments involving speech and text found that students in the personalised (P) group generated more creative and correct solutions than students in the non-personalised (N) group in a follow-up transfer test with an effect size of 1.00 and 1.60 respectively.

In the latest study, Moreno and Mayer (2004) studied the personalisation hypothesis in the domain of biology for a plant design activity. This research involved a computer-based science simulation game, where students learn about the biological features of plants. Students interact in a virtual environment and fly to a make believe planet that has certain environmental conditions and are asked to design a plant that has root, stem and leaf properties that would survive in those conditions. Guidance is provided by an on-screen agent, Herman the Bug, who not only guides students but also poses questions. Two different versions of the program were used, a personalised version and non-personalised version. Examples are given below.

> **Introduction to the Program** (Mayer and Moreno 2004, p.173)
> P version: You are about to start a journey where you will be visiting different planets. For each planet, you will need to design a plant. Your mission is to learn what type of roots, stem, and leaves will allow your plant to survive in each environment. I will be guiding you through by giving out some hints.
>
> N version: This program is about what types of plants survive in different planets. For each planet, a plant will be designed. The goal is to learn what type of roots, stem, and leaves allow plants to survive in each environment. Some hints are provided throughout the program.

The results showed that students studying the P version obtained significantly better outcomes in learning as measured by retention and transfer tests and found the program friendlier. Students in the P group obtained 28% more marks on the transfer test than students in the N group resulting in an extremely large effect size of 1.64 (Mayer and Moreno 2004).

Current research project

This work set out to test the personalisation hypothesis using first year university students studying chemistry. The e-learning environments chosen involved compulsory pre-laboratory work activities used to prepare students to carry out experiments in acid-base chemistry. This current project was conducted on a much larger scale (~600 students) than that of the previous research (~30 students). It should also be noted that the previous research involved psychology students and the presentation of material in the domain of biology and physics, while this study involves chemistry students with different levels of prior knowledge from the same domain as the material that was presented. In addition to simply investigating whether personalisation has an effect on academic performance in the domain of chemistry, this project also considers the importance of factors such as gender, language background – English speaking (ESB) or non-English speaking (NESB), and learning style preferences – degree of introversion (I) or extroversion (E).

Significance of the research

The examination of the differences in academic performance between students who completed a personalised versions of online chemistry modules and students who completed non-personalised versions will allow a better understanding of the way information should be phrased in online materials to best promote learning and improve academic performance in first year chemistry. Such information can give insight into the design and delivery of teaching materials to support learning in the future and is of significant interest since present chemistry teaching materials are mainly written in a non-personalised way. If personalised messages were found to have a positive effect on academic performance, the information is likely to have a significant impact on the design of such materials in the future.

Methodology

Participants

Three different groups of first year chemistry students participated in this study at the University of Sydney in 2005. All students were enrolled in a semester 2 chemistry units of study (UOS) available to students undertaking mainstream science qualifications after completing chemistry in semester 1. These UOS were CHEM1002 (Fundamentals of Chemistry 1B), CHEM1102 (Chemistry 1B) and CHEM1902 (Chemistry 1B – Advanced). All three units cover similar material, but differ in the level of assumed prior knowledge and the level at which material is presented. CHEM1002 students have either not completed chemistry for the Higher School Certificate (HSC), i.e., university entry level, or achieved comparatively poor results. CHEM1102 students have satisfactorily completed HSC chemistry, whilst CHEM1902 students have achieved a HSC chemistry mark above 80.

Study design – large group versus small group

There are many factors that can affect student learning and it is difficult to control and account for all of them. If such factors could be controlled as much as possible, then the data obtained about the effect of personalisation on academic performance would be more reliable. For this reason, a large group and small group of students were formed. The large group was used to investigate the personalisation hypothesis on a large scale. Students in the small group completed the online modules in a separate supervised session where fewer external factors were present to affect their behaviour. Academic performance of all students in the large group and the small group was examined in the same way by comparing the performance of students who completed the different versions of the modules. Methodologically, gathering data from a large group as well as focussing on a small group will allow conclusions of acceptable generality to be drawn, whilst still ensuring that results authentically reflect the experiences of students. Figure 1 shows a schematic diagram of the methodology and the different aspects of the project each group completed.

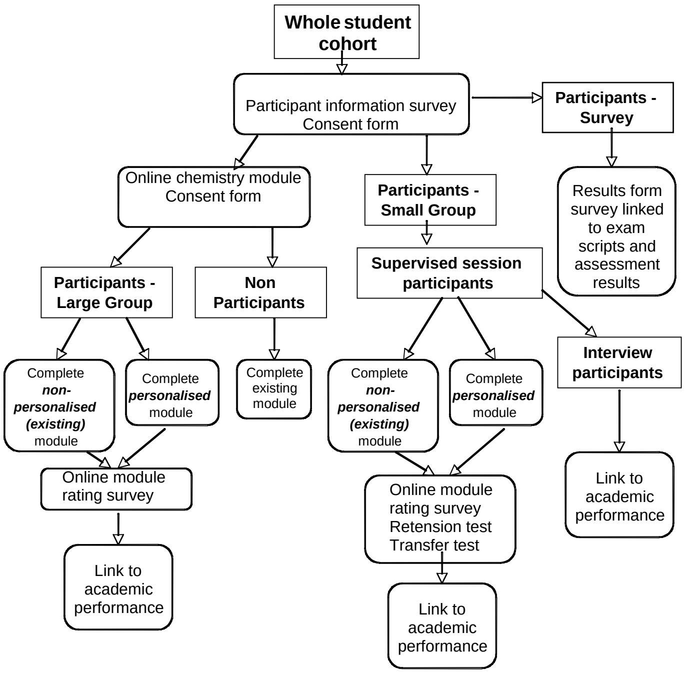

Figure 1. Schematic of methodology

Participant information survey

A survey was distributed to about 900 students during a laboratory session in semester 2, 2005. The purpose of this survey was to obtain information on particular student characteristics. These characteristics were gender, language background (ESB or NESB), and learning styles (degree of E or I). The learning styles preferences of students were determined using the 13 extrovert/introvert items from the current version of the Paragon of Learning Styles Inventory (Shindler and Yang 2002). Only these items were used since the greatest correlation between learning style preference and academic performance has been found for this Jungian dimension in the past (Yeung, Read and Schmid 2005).

Online pre-laboratory work modules

Students were asked to complete two online pre-laboratory work modules. These pre-laboratory work modules, which students must complete before each laboratory session, and form part of their assessment, were part of the current pre-work program. They were E18 – *Percentage ionisation of a weak acid* (predominantly involves calculations) and E21 – *Buffered and unbuffered solutions* (a more concept based module). Completing the modules involved students reading through content presented on the screen and answering some quiz questions. Students were allocated to either a P or N version of the modules depending on the last digit of their student identification number (SID). Students in the large group completed these modules in their own time wherever they wanted. Students in the small group completed the modules in a supervised session.

Small group – Additional retention and transfer questions

In order to better understand the effect of personalisation on academic performance, students in the small group (34 students) *also* completed a retention test and a transfer test following the completion of both online pre-laboratory modules. The purpose of the retention test was to determine what students remember from the modules while the transfer test was used to determine students' understanding. Making students complete these further tests immediately after completing the modules ensures that no additional external factors can influence the learning outcomes of these students and thus give us a better indication of the true effect of personalisation.

Module rating survey

Students were also asked to complete an online module rating survey after they finished both online modules in an attempt to determine whether personalisation affects students' opinions of the modules. Other questions the survey sought to answer were questions related to student's motivational level, student's perception of the modules helpfulness and user friendliness, and how students use the modules to assist their learning.

In-depth interviews

Interviews were conducted with eight students of the small group. Students were asked to provide more detailed responses for the module rating survey. During the interview students were also shown their retention/transfer test paper and were asked questions concerning different aspects of the paper. This allowed the interviewer to gain an insight into the methods students used to solve particular questions, especially the differences between students in the P and N groups. General questions about the modules were also asked with particular attention paid to the language used in the modules.

Results

Academic performance was measured by marks obtained in the online quizzes, which immediately followed the presentation of content in the online chemistry modules for E18 and E21. A total of 630 students gave consent to participate in the study and their results were used in the analysis of the large group.

Large group

Independent sample t-tests were conducted to determine whether there was a difference in academic performance of students who completed the P or N versions of the online chemistry modules. No significant difference in quiz performance was found for E18 (t_{628}=-1.794, p=0.073) and E21 (t_{219}=-0.256, p=0.798). The quiz marks of students who completed both online modules were then summed to produce a *total mark*, and a further t-test showed no significant difference between the P and N group (t_{615}=-1.299, p=0.195). These results were consistent across each UOS. Since no differences were found between the overall marks of students in each group, χ^2 analyses were conducted to determine whether there were differences in the distribution of marks for E18, E21 and total mark between the P and N group. Again, it was found that there were no significant differences between the P and N group for both E18 (χ^2=8.877, df=5, p=0.114), E21 (χ^2=5.480, df=5, p=0.360) and total mark (χ^2=12.113, df=9, p=0.207) as shown in Figure 2.

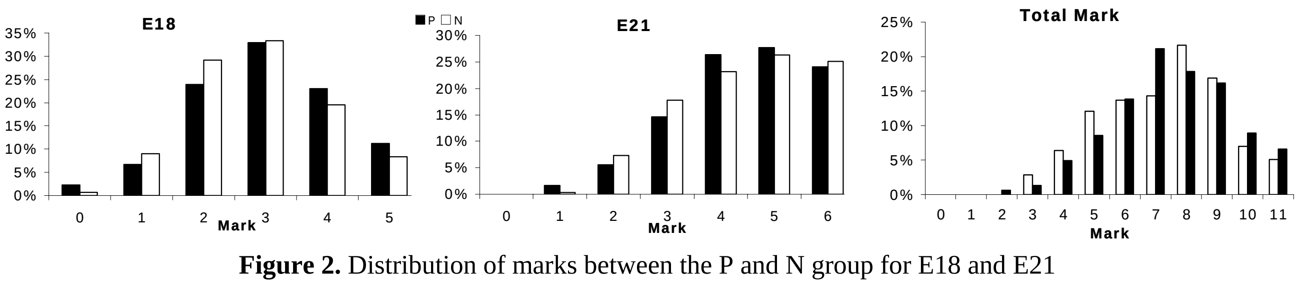

Figure 2. Distribution of marks between the P and N group for E18 and E21

Individual questions from pre-work

Individual quiz questions were looked at in detail to determine whether there were differences in performance between the P and N groups for particular questions. After conducting a series of independent sample t-tests, no significant differences found between the P group and the N groups.

Gender

Independent sample t-tests were conducted to determine whether there was a difference in mean online quiz marks between students of different gender who completed the P or N versions of the modules. It was found that there was no significant difference in quiz performance between the P or N group of males for E18 (t_{276}=-1.370, p=0.172), or E21 (t_{274}=-0.546, p=0.585), as well as females for E18 (t_{347}=-1.179, p=0.239) or E21 (t_{340}=0.348, p=0.728).

Language background

Independent sample t-tests confirmed NESB students in the P group performed significantly better than students in the N group for E18 (t_{108}=-2.350, p=0.021, es=0.45). This was the only significant result when investigating language background.

Learning style

The quiz marks for each of the scores of the EI dimension were averaged and a 95 % confidence interval for the mean of the quiz performance was constructed. When the average quiz performance for E18, E21, and total mark was plotted against EI score a very small correlation emerged following the construction of a weighted trendline (see Figure 3). These graphs show a scatter of points with no clear pattern and the confidence intervals are so large that they overlap each of the lines. This indicates that there is no difference in performance between students in the P group and the N group.

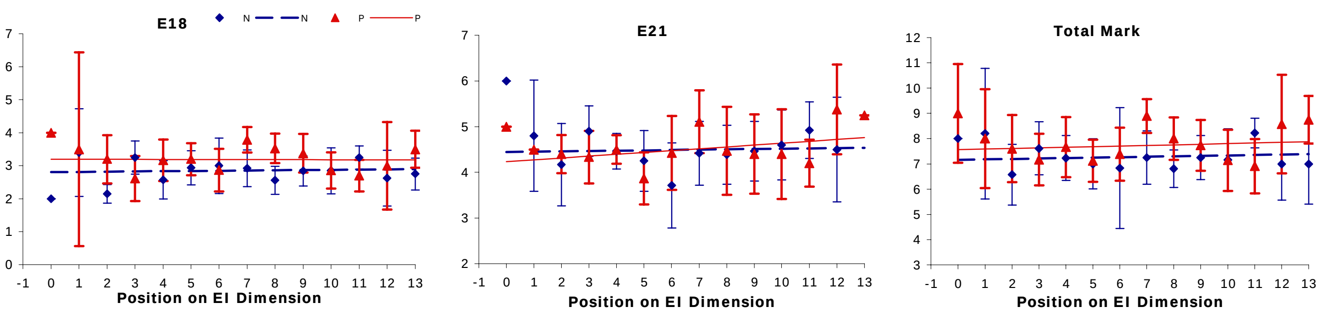

Figure 3. Correlation between learning style and performance between the P and N groups

Small group

Similar as for the large group, independent sample t-tests were conducted to determine whether there were differences in quiz performance between students in the small group who completed the P or N version for the modules. No significant differences were found for E18 (t_{32}=-1.393, p=0.173) or E21 (t_{32}=0.000, p=1.000). Furthermore, independent sample t-tests also showed that there were no differences in performance of students in the P and N groups for the additional retention (t_{32}=1.173, p=0.249) and transfer (t_{32}=0.793, p=0.434) tests.

Student characteristics – gender, language background and learning style

Further investigation of the personalisation effect on academic performance and student characteristics found a significant difference in that NESB students in the P group performed significantly better than the N group for E21 (t_8=-3.667, p=0.001, es=1.95). However, this result was not seen in the large group of about 100 students. Generally, there were no significant differences between the P and N groups in the small group.

Program rating survey and interviews
Chi-square analyses were conducted to determine whether there were differences in the distribution of answers for the program rating survey between the P and N groups. No significant differences were found, indicating that students in both groups had the same opinions about the online modules despite the different versions they completed. These results were further verified in the interviews where students in both the P and N groups made the same comments about different aspects of the modules, even though they completed two different versions.

Discussion

The results show that personalisation of online material in chemistry does not seem to have an effect on academic performance of chemistry students. These results are quite different from those obtained by previous research (e.g. Moreno and Mayer 2000). That research involved psychology students who did not study in the domain under investigation (Moreno and Mayer 2000; Mayer, Fennell, Farmer and Campbell 2004; Moreno and Mayer 2004). These students were given material in the domain of biology and physics, which they would not have been very familiar with. Our study involved chemistry students who were presented with chemistry content. So, perhaps personalisation only improves academic performance of students who are studying in an unfamiliar area. Since students in the current project are chemistry students being presented with chemistry content, these students may have experienced interference from other information while completing the modules. The material used in the online modules was also presented in lectures and assignments. This prior knowledge may have interfered and prevented the full effect of personalisation to be realised. Alternatively, personalisation may only improve academic performance in the domains of biology and physics but not chemistry. Further investigation is required to determine the actual reasons why the improved academic performance seen in previous research was not evident in the current project.

Our study involved over 600 students while previous work involved only about 30 students. The majority of students in this study completed the online modules in an authentic learning environment, i.e., at their own pace, time and space. In contrast, previous research was conducted in a laboratory setting, similar to the small group used in this study. As mentioned earlier, investigations of the large group found NESB students in the P group performed significantly better than NESB students in the N group for E18. However, this difference was not observed in the small group. Instead, investigations of the small group showed NESB students in the P group performed significantly better than NESB students in the N group for E21. This result was not seen for the large group. Despite these conflicting results, which may be attributed to the small numbers in the small group, it is likely that personalisation has a positive influence on academic performance of NESB. This has significant implications for the design of future online teaching materials for these students. Further research is needed to verify the true effect of personalisation, with particular attention paid to NESB students.

Conclusion

Our research has shown that, contrary to previous findings in the domains of biology and physics, personalisation of online chemistry material does not influence academic performance of chemistry students depending on gender and learning style. However, non-English speaking background (NESB) students in the P group were found to perform significantly better than NESB students in the N group. This observed benefit of personalisation for NESB suggests that consideration needs to be taken in the design of online materials for these students in order to effectively promote student understanding. If certain phrasing of online material is able to promote learning and improve performance, then any new research or information in this area is likely to have a significant impact on the design of such materials in the future, since current materials are mainly written in a non-personalised way. Further investigation in various domains and large sample sizes is required to further validate the existence of the personalisation hypothesis. Moreover, investigations into the mechanism by which personalisation can affect student learning, e.g. changes in interest or motivational levels, can provide a greater insight into the way students use online materials in their learning. Consideration of this information is worthwhile before making any major changes to the design and delivery of teaching materials in the future.

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