The personalisation hypothesis in e-learning: Further developments

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Introduction

Student learning and understanding has the potential to improve with the use of computer-based multimedia environments. Such environments have been expected to offer a powerful effective means of delivering material and enhancing learning (Mayer and Moreno 2002). Presently, there is much research activity investigating best practices for the design of multimedia instructional materials for creating effective e-learning environments. Several principles have already been established and tested such as the *multiple representation principle* meaning that it is better to present explanations as words and pictures rather than solely words (Mayer and Moreno 2002).

The personalisation hypothesis
One particular area of interest concerns the personalisation hypothesis. Moreno and Mayer (2000) predicted that students who learn from personalised messages would recall more information and solve problems better than those learning from non-personalised messages. They conducted experiments using multimedia explanations about lightning formation accompanied by personalised text (first person, more conversational style) or non-personalised text (third person, more formal style). The experiments found 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 1.60. In a later study, Moreno and Mayer (2004) studied the personalisation hypothesis in the domain of biology. Findings revealed that students in the P group obtained significantly better outcomes in learning. They averaged 28% more marks on the transfer test than students in the N group resulting in a large effect size of 1.64 (Moreno and Mayer 2004).

Given such a large effect it was considered important to investigate whether the personalisation hypothesis could also be observed in chemistry. The examination of the differences in performance between students who complete P and N versions of online chemistry material will allow a better understanding of the way information should be phrased to best promote learning and improve performance in chemistry. That understanding 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 performance, the information would have a significant impact on the design of such materials in the future. Consequently this study set out to test the personalisation hypothesis using first year university chemistry students. The e-learning environments chosen involved compulsory pre-laboratory work activities used to prepare students for the laboratory. In addition to simply investigating whether personalisation has an effect on academic performance in chemistry for the whole cohort, this project also considers the importance of factors such as gender, and language background – English speaking (ESB) or non-English speaking (NESB).

Methodology

Participants
Two cohorts of three different groups of first year students who are mainly undertaking mainstream science qualifications participated in this study at The University of Sydney (see Table 1).

Table 1. Summary of the different cohorts and groups who participated in the study

Group	Year	Description
CHEM1001 (Fundamentals of Chemistry 1A)	Semester 1, 2008	Students have not completed chemistry for the Higher School Certificate (HSC) (university entry level), or achieved poor results
CHEM1101 (Chemistry 1A)	Semester 1, 2008	Students have satisfactorily completed HSC chemistry
CHEM1901 (Chemistry 1A – Advanced)	Semester 1, 2008	Students have achieved a HSC chemistry mark above 80 %
CHEM1002 (Fundamentals of Chemistry 1B)	Semester 2, 2005	Satisfactorily completed CHEM1001
CHEM1102 (Chemistry 1B)	Semester 2, 2005	Satisfactorily completed CHEM1101
CHEM1902 (Chemistry 1B – Advanced)	Semester 2, 2005	Satisfactorily completed CHEM1901
Bridging course (BC)	Summer, 2007	Students with weak or no chemistry background enrolled in a course designed to prepare students for university chemistry

Study design – large group versus small group
Students were assigned to P and N groups and formed a small and large group. Students in the large group completed the online modules in their own time and space. Students in the small group completed the modules in a supervised session. All students completed a test directly after the module. The performance in these tests was compared for students in the P and N groups. Students in the small groups also undertook retention and transfer tests. Methodologically, gathering data from a large group as well as focusing on a small group allows conclusions of acceptable generality to be drawn, whilst still ensuring that results authentically reflect the experiences of students.

Participant information survey
A survey was distributed to about 900 students during a laboratory session in Semester 2, 2005, about 1100 students in Semester 1, 2008, and approximately 200 students enrolled in the 2007 bridging course. The purpose of this survey was to obtain information on particular student characteristics, including gender and language background (ESB or NESB).

Online pre-laboratory work modules
Students were asked to complete online pre-laboratory work modules (see Table 2). These form part of their assessment (except for BC students) and must be completed before the laboratory session.

Table 2. Online modules students completed in the study

Semester 2, 2005	Semester 1, 2008	Bridging Course 2007
E18 (Percentage ionisation)	*E1* (Photochemistry)	Stoichiometry
E21 (Buffered solutions)	*E2* (Solubility)	
	E6 (Gas properties)	
	E10 (Thermodynamics)	
	E11 (Molecular models)	
	W1 (Stoichiometry) – *CHEM1001/1101 only*	
	E12 (Inorganic solids) – *CHEM1901 only*	

Completing the modules involved students reading through content presented on the screen (which included some static images) 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) in Semester 2, 2005 or receipt number for the BC students. In Semester 1, 2008, students were randomly assigned using student administration software to either the P or N groups. The modules were personalised similar to previous research, e.g. the word 'the' was replaced by the word 'you'.

Small group – retention and transfer questions
Students in the small group (34 in Semester 2, 2005 and 14 in Semester 1, 2008) completed retention and transfer tests following completion of 2 online pre-work modules (E18 and E21 in 2005 and E6 and E10 in 2008). The purpose of the retention test was to determine students' recall of the modules while the transfer test (multiple choice and short answer questions based on the material student have viewed) 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 student learning, giving us a better indication of the personalisation effect.

Module survey and in-depth interviews
Students were also asked to complete an online module survey after they finished the modules in an attempt to determine whether personalisation affects students' perceptions of the modules. The survey also sought to answer questions related to students' motivational levels, perception of the modules helpfulness and user friendliness, and how students use the modules to assist their learning. In addition, interviews were conducted with 8 students of the small group in Semester 2, 2005 and 5 students in Semester 1, 2008. Students were asked to provide more detailed responses for the module survey. General questions about the modules were also asked with particular attention paid to the language used in the modules, to try and determine any differences between the P and N groups.

Results

Academic performance was assessed using marks obtained in the online quizzes, which students completed directly after the presentation of content in the online chemistry modules. In Semester 2, 2005, a total of 630 (67 %) students gave consent to participate in the study and their results were used in the analysis of the large group. In Semester 1, 2008 a total of 6 online chemistry modules were used for participants in all courses. A total of 824 (87 %) students gave consent to participate in the study and their results were used in the analysis of the large group for Semester 1, 2008. A total of 9 students (5 %) from the 2007 bridging course gave consent to participate in the study.

Large group – Semester 2, 2005
Independent samples t-tests were conducted to determine whether there was a difference in academic performance for students who completed the P or N versions of the online chemistry modules. No significant difference in quiz marks 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 course. 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, no significant differences between the P and N groups were found.

Student characteristics – gender and language background
Further investigations of the personalisation effect on performance took student characteristics into account. We found a significant difference for NESB students where independent samples t-test confirmed the P group performed significantly better than the N group for E18 (t_{108}=-2.350, p=0.021, es=0.45). However, there were no significant differences between the P and N groups for gender.

Large group – Semester 1, 2008

In Semester 1, 2008, the quiz marks of all students in a course who completed either all P or all N online modules were summed to produce a *total mark* for the common modules that students in all courses completed. A further *total mark_1901,* included the marks for E12 that only the CHEM1901 students completed, while *total mark_1001* and *total mark_1101* included the marks for W1 that only the CHEM1001 and CHEM1101 students completed. Independent sample t-tests were conducted to determine whether there was a difference in academic performance between students who completed the P or N versions of the online chemistry modules. The results are summarised in Table 3.

No significant differences were found for *total mark* for students in CHEM1101 or CHEM1901. For CHEM1001, however, a significant difference in performance was found between the P and N groups. When including the E12 exercise for the CHEM1901 students (*total mark_1901*), a significant difference was found, which stems from the different performance for that particular module (*mark E12*). A separate independent samples t-test was conducted for E12, which determined that the P group performed significantly better than N group for E12 as shown in Table 3a. The data for *total mark_1001* or *total mark_1101* (*i.e.* including W1) did not show a normal distribution so a Mann Whitney test was conducted to determine if there were any differences in performance for students in CHEM1001 or CHEM1101. A summary of the results is shown in Table 3b. Students in the P group performed significantly better than those in the N group for CHEM1001 while there was no significant difference between CHEM1101 students in the P and N groups.

Table 3. (a) Summary of differences (t-test results) between the P and N groups in Semester 1, 2008 and (b) Summary of differences (Mann Whitney results) between the P and N groups in Semester 1, 2008.

(a)		t	df	p
CHEM1001	Total mark	-2.400	229	0.0170
CHEM1101	Total mark	-1.341	332	0.181
CHEM1901	Total mark	-1.685	86	0.0960
	Total mark_1901	4.631	83	0.000
	Mark E12	-2.324	85	0.0230

(b)		U	p
CHEM1001	Total mark_1001	5187.5	0.043
CHEM1101	Total mark_1101	11420.5	0.302

Large Group – Bridging course

Independent sample t-tests were conducted to determine whether there was a difference in academic performance of students in the BC who completed the P or N versions of the stoichiometry online chemistry modules. No significant difference in quiz performance was found ($t_7 = -1.40$, $p = 0.206$).

Small Group – Semester 2, 2005

Independent sample t-tests were conducted to determine whether there were differences in quiz marks between students in the small group who completed the P or N version. No significant differences were found for E18 ($t_{32}=-1.393$, $p=0.173$) or E21 ($t_{32}=0.000$, $p=1.000$). 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.

A significant difference was found only for E21 for the NESB students in the P group who performed significantly better than the N group ($t_8=-3.667$, $p=0.001$, es=1.95). However, this result was not seen in the large group of about 100 students.

Module survey and interviews

Chi-square analyses were conducted to determine whether there were differences in the distribution of responses for the module survey between the P and N groups. No significant differences were found when looking at all students, indicating that students in both groups had the same perceptions of 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 similar comments about different aspects of the modules, despite completing two different versions.
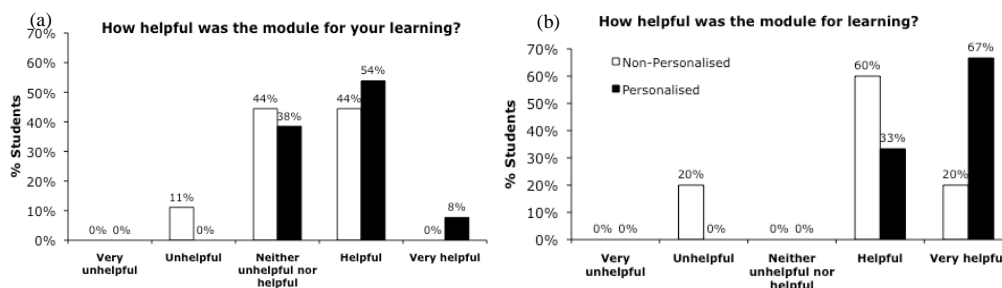

Figure 1. Examples of student responses for the module rating survey for each version of the module for (a) Fundamentals students in Semester 1, 2008 and (b) BC students in 2007

However, differences were found for Fundamentals students. The example in Figure 1a shows a difference in response distribution for Semester 1, 2008. Although the number of students who completed the survey in the bridging course was small, a clear trend emerged. The P group found the module more helpful and engaging than the N group. The P group also felt that less effort was required to learn the material and found it easier to follow the explanations than the N group. An example of the difference in distribution is shown in Figure 1b.

Discussion

Our study shows that personalisation of online material in chemistry does have an effect on academic performance of chemistry students in certain instances but not in general. These results seem quite different from those obtained by previous research (e.g. Moreno and Mayer, 2000). However, there are several distinct differences between these studies. Previous research involved psychology students who did not study in the domain under investigation (Moreno and Mayer, 2000, 2004). These students were given material in an unfamiliar area of biology and physics. Our study involved chemistry students with varying levels of prior knowledge who were presented with chemistry content. In addition, our study (approximately 600 students in Semester 2, 2005 and approximately 800 students in Semester 1, 2008) was conducted on a much larger scale than previous research (approximately 40 students in both cases). Furthermore 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. Our initial study in 2005 found virtually no evidence for a difference in performance for students using personalised or non-personalised material. Considering these differences between previous studies and our own findings we concluded that the explanation may be the expertise reversal effect.

It has been shown in empirical studies (Kalyuga, Chandler and Sweller 1998; Yeung, Jin and Sweller 1998) that instructional design that is highly effective for inexperienced learners can lose its effectiveness or even have negative consequences for learners with more experience (Kalyuga, Chandler and Sweller 2003). According to Sweller, van Merrienboer and Paas (1998), the level of learner expertise in a domain primarily influences the extent to which a learner can organize schemas and information in working memory. For inexperienced learners who receive no guidance in how to organise schemas, effective instructional material can act as a substitute for missing schema and as a means of constructing schemas. Effective instruction provides the necessary instructional guidance while also minimising cognitive load (Sweller 1999). However, instructional material that guides novices may be redundant to more experienced learners (Kalyuga, Chandler and Sweller 2003).

So, personalisation might only improve academic performance of students who are studying in an unfamiliar area. The participants in the 2005 study were already in Semester 2 of first year chemistry and therefore may have been too advanced in their chemistry knowledge to show an effect. Consequently we extended the study to BC students in 2007 and Semester 1 students in 2008. While BC students in the P group performed better than the N group, the small number of participants did not allow any conclusions from this study alone. It did, however, support the view that students with a weak background in a domain may benefit from personalised teaching material. Despite the small number of BC participants, responses in the module survey show that students in the P group found the module more helpful and engaging. This also indicates that the P version may have a positive influence on student perception of the module, for those with a weak chemistry background. There is also no evidence to suggest that personalised language has a negative effect on advanced students.

The Semester 1, 2008, findings show that students with the weakest background in the P group performed better than the N group. No difference was found for the students in CHEM1101 and CHEM1901 for all the common modules. Interestingly, performance in the E12 module was better for the P group than the N group, which may seem contrary to our other findings, since CHEM1901 students have the best chemistry background and are generally very high achievers. However, the E12 module includes new material on inorganic solids that has not been covered elsewhere. It therefore appears that even high achievers benefit from personalised instruction material when studying in an unfamiliar area. Furthermore, Semester 2, 2005, investigations found NESB students in the P group did significantly better than those in the N group. Despite inconsistencies being found, which may be attributed to the small numbers in the small group and possibly random variation, it is likely that personalisation has a positive influence on performance of NESB students.

Conclusion

Our research has shown that positive effects of personalisation may not be as general as previous findings first assumed. Personalised chemistry material does not influence performance of all chemistry students. Students with a weak chemistry background or unfamiliarity in certain areas do improve their performance when exposed to personalised text rather than non-personalised text, which there is no change for other students. The expertise reversal effect might explain these results, yet further investigations need to be conducted to verify this conclusion. Non-English speaking background students in the P group were found to perform better than those in the N group. Therefore, consideration needs to be taken when designing online materials to effectively promote understanding. Since current materials are mainly written in a non-personalised way, any new research in this area is likely to have an impact on the design of such materials, especially if certain phrasing of material can promote learning. More research in various domains and with larger samples 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. considering changes in interest or motivational levels, can provide a greater insight into the way students use online materials when learning. Consideration of this information is worthwhile before making any major changes to the design and delivery of teaching materials in the future.

References
Kalyuga, S., Chandler, P. and Sweller, J. (1998) Levels of Expertise and Instructional Design. *Human Factors,* **40**, 1–17.
Kalyuga, S., Chandler, P. and Sweller, J. (2003) The Expertise Reversal Effect. *Educational Psychologist,* **38**, 23–31.

Mayer, R. E., Fennell, S., Farmer, L. and Campbell, J. (2004) A Personalisation Effect in Multimedia Learning: Students Learn Better When Words Are in Conversational Styles Rather Than Formal Style. *Journal of Educational Psychology,* **92**(2), 389–395.

Mayer, R. E. and Moreno, R. (2002) Aids to Computer-Based Multimedia Learning. *Learning and Instruction,* **12**, 107–119.

Moreno, R. and Mayer, R.E. (2000) Engaging Students in Active Learning: The Case for Personalised Multimedia Messages. *Journal of Educational Psychology,* **92**(4), 724–733.

Moreno, R. and Mayer, R.E. (2004) Personalised Messages That Promote Science Learning in Virtual Environments. *Journal of Educational Psychology,* **96**(1), 165–173.

Sweller, J. (1999). *Instructional Design in Technical Areas.* Melbourne, Australia: ACER Press.

Sweller, J., van Merrienboer, J.G. and Paas, F. (1998) Cognitive Architecture and Instructional Design. *Educational Psychologist,* **10**, 251–296.

Yeung, A., Jin, P. and Sweller, J. (1998) Cognitive Load and Learner Expertise: Split-Attention and Redundancy Effects in Reading with Explanatory Notes. *Contemporary Educational Psychology,* **23**, 1–21.

Yeung, A., Schmid, S., George, A. and King, M. (2008) The personalisation hypothesis in e-learning: Further developments. In A. Hugman and K. Placing (Eds) *Symposium Proceedings: Visualisation and Concept Development*, UniServe Science, The University of Sydney, 145–151.