Nico: An Environment for Mathematical Expression in Schools

Thank you for agreeing to participate in the user study for my Part II Project. *Nico* is a piece of educational software designed to aid learners in the visualisation of mathematical problems, by separating out the constituent parts of a calculation into distinct visual units on-screen.

The purpose of this study is to ascertain how well *Nico* achieves its goal of providing a clear, accessible, interactive means of calculation, and to gather feedback on how the application could be improved. The study also aims to compare *Nico* to traditional mathematical methods.

Please review and sign the attached Statement of Informed Consent (Section 1) and please feel free to ask any questions you may have about it.

1   Statement of Informed Consent

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Statement of Informed Consent

I state that I am over 18 years of age and wish to participate in a program of research being conducted by Philip Yeeles at the University of Cambridge. I acknowledge that this study has been approved by the University of Cambridge Computer Laboratory Ethics Committee.

The purpose of this research is to assess the usability of a graphical notation and software application for representing mathematical calculations in a graphical manner.

The study involves the use of the application whilst being supervised. I will be asked to complete certain tasks both with and without the application, and I will also be asked open-ended questions about the application and my experience as a user thereof.

All information collected in the study is confidential, and my name will not be identified at any time. I understand that I may ask questions or terminate my involvement in the study freely and at any time without consequence.

I acknowledge that my (anonymised) responses may be published in the final report, and that this report will be made publicly available from the University of Cambridge Computer Laboratory Library and from GitHub.

Signed:

Name:

Date:

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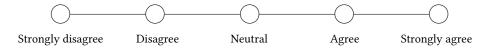
2 Study

Before we begin, please answer the following questions.

- Have you used *Nico* before (circle as appropriate)?

<div align="center">Yes   No</div>

- How well do you agree with the following statement (cross as appropriate)?
  I am confident in my ability to calculate answers to simple mathematical problems.

Strongly disagree	Disagree	Neutral	Agree	Strongly agree

Thank you. You will now be issued a group number.

- If you are in Group 1, please proceed to Section 2.1.

- If you are in Group 2, please proceed to Section 2.2.

If you would like to stop at any point, please don't hesitate to let me know.

2.1 *Nico*

In this section, you will use *Nico* to solve some simple mathematical problems. The purpose of this section is to evaluate how well *Nico* performs in comparison with manual calculation. We will be keeping a record of the time taken to complete each problem, but please do not let this make you feel rushed. Work at a pace that is normal and comfortable for you.

Before we begin the tasks, please watch the instructional video `tut.ogm` for a briefing on how to use *Nico* and an explanation of its controls.

Now that you have done this, please spend 5 minutes experimenting with *Nico*. Open the application and load the file `qs/blank.nqs` using the file chooser. As you explore, please tell me your thoughts about the application.

Now, let us move on to the problems. Please close the application and open it again, this time loading the file `qs/user-study.nqs`. You will be presented with a series of problems to solve using *Nico*; please solve them.

Thank you very much.

- If you are in Group 1, please continue to Section 2.2

- If you are in Group 2, please continue to Section 3

2.2   Manual Calculation

In this section, you will solve some simple mathematical problems using pen and paper. The purpose of this section is as a control, to compare to your results using *Nico*. Once again, we will be keeping a record of the time you take to complete each question, but please do not let this make you feel rushed. Work at a pace that is normal and comfortable for you, and don't forget to show your working.

Let us begin.

1. *2+3*

2. *9÷3*

3. *1+2+3+4+5*

4. *(2×4)+(3-5)*

5. *((3×4)÷(3+3))×8*

6. *((1+2+3+4+5)+(2×4×6×8×10))×1×2×(1+2+3+4+5)*

7. *12+14*

8. *247×35*

9. *120÷((2×10)+5+5)*

10. *((2+5)×(6÷2)×(9-8))+((3+4)-(5×6))+120*

Thank you very much.

- If you are in Group 1, please continue to Section 3
- If you are in Group 2, please continue to Section 2.1

3   Questions

3.1   Notation

When using the system, what proportion of your time (as a rough percentage) do you spend:

1. Searching for information within the notation ☐ %

2. Translating substantial amounts of information from some other source into the system ☐ %

3. Adding small bits of information to a description that you have previously created ☐ %

4. Reorganising and restructuring descriptions that you have previously created ☐ %

5. Playing around with new ideas in the notation, without being sure what will result ☐ %

3.2   Cognitive Dimensions

3.2.1   Visibility and Juxtaposability

1. How easy is it to see or find the various parts of the notation while it is being created or changed? Why?

2. What kind of things are more difficult to see or find?

3. If you need to compare or combine different parts, can you see them at the same time? If not, why not?

3.2.2   Viscosity

1. When you need to make changes to previous work, how easy is it to make the change? Why?

2. Are there particular changes that are more difficult or especially difficult to make? Which ones?

3.2.3 Error Proneness

1. Do some kinds of mistake seem particularly common or easy to make? Which ones?

2. Do you often find yourself making small slips that irritate you or make you feel stupid? What are some examples?

3.2.4 Closeness of Mapping

1. How closely related is the notation to the result that you are describing? Why?

2. Which parts seem to be a particularly strange way of doing or describing something?

3.2.5 Role Expressiveness

1. When reading the notation, is it easy to tell what each part is for in the overall scheme? Why?

2. Are there some parts that are particularly difficult to interpret? Which ones?

3. Are there parts that you really don't know what they mean, but you put them in just because it's always been that way? What are they?

3.2.6 Hidden Dependencies

1. If the structure of the calculation means that some parts are closely related to other parts, and changes to one may affect the other, are those dependencies visible? What kind of dependencies are hidden?

2. In what ways can it get worse when you are creating a particularly large description?

3.2.7 Progressive Evaluation

1. How easy is it to stop in the middle of creating some notation, and check your work so far? Can you do this any time you like? If not, why not?

2. Can you find out how much progress you have made, or check what stage in your work you are up to? If not, why not?

3. Can you try out partially-completed versions of the calculation? If not, why not?

3.2.8 Provisionality

1. Is it possible to sketch things out when you are playing around with ideas, or when you aren't sure which way to proceed? What features of the notation help you to do this?

3.2.9 Secondary Notation

1. Is it possible to make notes to yourself, or express information that is not really recognised as part of the notation?

2. If it was printed on a piece of paper that you could annotate or scribble on, what would you write or draw?

3. Do you ever add extra marks (or colours or format choices) to clarify, emphasise or repeat what is there already?

3.3 Feedback

1. Do you find yourself using this notation in ways that are unusual, or ways that the designer might not have intended? If so, what are some examples?

2. After completing this questionnaire, can you think of obvious ways that the design of the system could be improved? What are they? Could it be improved specifically for your own requirements?

Thank you very much for your help with my project! Your responses will remain confidential, although they are liable to appear in an anonymised form in the final report, of which a copy will be retained by the University of Cambridge Computer Laboratory Library (`http://www.cl.cam.ac.uk/library/`). The final report will also be available via my repository at GitHub (`http://github.com/loomcore/nico`).