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A Revision Tool for Learning Data Modelling with Diagrams

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This article is extracted from a COLMSCT CETL (Centre of Excellence for Teaching and Learning) interim report on a project to produce a revision tool for learning data modelling that is intended for use on the forthcoming database course M359. The work was carried out as part of the author's COLMSCT teaching fellowship.

Abstract

This article provides the history of the project to-date (January to October 2006) and discusses the evaluation of a prototype version of the tool. Further discussion of the tool itself and of the research that supports it can be found in the references.

Introduction

The aim of this project is to build a piece of software, called the 'Revision Tool', to enable students to learn about data modelling using Entity-Relationship diagrams. The software enables a student to draw an ER-diagram that models a given scenario and then automatically marks the diagram and provides feedback. The software tool currently has 10 scenarios available for revision purposes. The automatic marking and feedback process is being developed as a separate research project. The COLMSCT project is about exploiting this research by building and evaluating a revision tool for students on M359.

An initial prototype (proof of concept) had already been built prior to the start of the COLMSCT project. Therefore, the first part of the project was to develop the Revision Tool into a fully featured piece of software that could be evaluated by students learning to draw ER diagrams.

The primary purpose of the evaluation would be in terms of usefulness – would the tool be useful for revision purposes? A secondary aim would be to determine the tool's usability. To this end a questionnaire was developed with the twin aim of investigating usefulness and usability.

The upgraded prototype together with documentation and questionnaire was sent to about 80 students on M358 who had volunteered to take part in the trial. In the event, 28 responses were received which were analysed (see Appendix 1). The outcome of the evaluation was that the tool was indeed useful but that there were a number of usability issues that needed to be rectified (see Appendix 2).

It was always envisaged that a second version of the tool would be developed as a result of the feedback, and re-evaluated. To this end, the tool has been amended in the light of

student feedback and is currently (October 2006) with the same volunteer students for re-evaluation.

The Tutor Tool

The first version of the revision tool that was sent to the volunteer evaluators had a small number of fully worked-through questions (using scenarios of the type normally found in assignments and exams on M358). For the second version of the tool, further complete questions needed to be constructed. This posed a real problem because the data required by the tool is relatively complex and difficult to get right in a manual process. Therefore, it was decided to build a software tool (called the 'Tutor Tool') which would support the generation of this data.

The Tutor Tool was developed to enable data relating to the scenarios, specimen solutions, feedback relationships, and marking schemes to be input in a relatively simple manner. This was not an original aim of the project, but has been invaluable in populating the Revision Tool with appropriate data. It will also be of immense value in the future when creating the data for the new course M359.

Evaluation of the Revision Tool

The Revision Tool, otherwise known as the Exerciser, is a software tool that supports the learning of ER-diagramming for data modelling, was tested on volunteer M358 students during May 2006. Students on M358 were asked to volunteer to test out the software. This request occurred just before TMA02 (which included questions on ER-diagramming). Approximately 80 students volunteered to try the software, of whom 27 returned the questionnaire related to the usability and usefulness of the tool. Another student sent a comprehensive report on the tool but did not directly address the specific questions on the questionnaire. A copy of the questionnaire and summary responses is attached as Appendix 1.

Summary of student responses to the usability and usefulness questionnaire

The tool has 10 reasonably demanding questions for students to attempt (the questions were of an equivalent standard to those normally found in TMA questions). On average, the students attempted over 4.4 questions each which is certainly enough to gain a good impression of the usefulness and usability of the tool. The main reasons for not attempting more questions were either that they had completed enough questions to satisfy themselves that they understood ER-diagramming adequately or a lack of time with several students citing the imminent TMA as the main reason why they could not complete more questions. Several students said that they would be returning to the tool during their revision. We can conclude, therefore, that the responses to the questionnaire were based on a sufficiently good understanding of the tool and its capabilities.

All the students who returned the questionnaire said that the tool was helpful in their studies and 6 volunteered that the tool was 'very' helpful. All students said that they would recommend the tool to other students with 6 volunteering that they would 'definitely' recommend the tool. Most students provided additional positive comments on the usefulness of the tool.

In terms of usability, the average time to become familiar with the tool was just over 13 minutes with most students quoting 10 minutes. Of the 28 students who responded, 21 said that they found the tool easy to use, 3 felt that it was not easy to use and 4 did not respond to the question.

The responses indicated that the tool contained a number of faults (software errors) as well as some annoying behaviours. In particular, many students found that they accidentally created multiple unwanted boxes which they found difficult to delete. When coupled with the fact that the instructions for the tool (accessed via the tool's help menu) were both incorrect and incomplete, it is remarkable that these students did not give up using the tool. No student reported that the issues with usability detracted from the usefulness of the tool.

Student Opinions

The following are the voluntary remarks made by students.

1. I would like to have a go at any further versions of this tool, as I found it a great learning experience.
2. This is a tool that is well overdue. Having downloaded many sample ERD programs and found them all to be extremely complicated to use and understand, or having different components that don't match what we are being taught on the OU courses, or that only allow you to have a maximum of five relations in the sample, this is a godsend. Many, many thanks.
3. It would be useful to have a tool like this to use for the course, especially at present as majority of people are unable to create these on their computers.
4. I love it – being able to seeing where parts of the diagram come from is magic. Well done and thank you!
5. I particularly liked the feature in 'Mark diagram' that gave a % of match to the solution – it gave me hope! ... Thanks for the opportunity to test out this tool – it will prove very useful in the weeks and months to come.
6. Although I only have limited time at the moment, I will examine the other questions and use this tool for my revision. Overall looks like it will be a really good tool.
7. Despite my above comments picking out several improvements, I was generally happy with the application. Would be happy to be involved testing updated versions of this tool. Would it be possible to obtain the source code out of interest? Expect this to be a "no" due to copyright issues, but would just be interested to see how it works.
8. Good visual tool.
9. Good tool, which has been and still will be, helpful to me!

10. I had to do some considerable thinking with the constraints for participation conditions in Q9 on the relation for relationships method. Good revision, but maybe the course notes could be more specific about how participation conditions are represented when using this method. I am still mulling this over.....a few days later, tackling the TMA, I read the course notes again, then came back to Q9 AND Q10.....and hey presto.....working through these exercises really brought the whole relation for relationship method into perspective! Thank you!
11. I enjoyed using the software and thought that it was very helpful in enhancing my understanding of E-R diagrams. If M358 was not in its last presentation I would think this would be a valuable tool to help improve modelling understanding for students.
12. I believe that the ER Tool provides useful practical examples to help students understand Entity-Relation modelling.
13. I linked the explanation provided in Q1 describing the origin of the selected element.
14. This will be a very useful tool for M358 and related courses.
15. It was the final piece of the jigsaw for me. It was a good opportunity to test understanding of the theory of the course.
16. A very useful tool which helped me a lot.

Conclusions

We conclude that the students who responded found the tool to be very useful despite its usability deficiencies. There was little criticism of the main functionality of the tool and indeed, many students said that they wished that such a tool had been available as part of the course materials.

All responders provided useful feedback including 'bug' reports and suggestions for improvements. The tool is now undergoing a minor redesign to improve its usability by removing the errors, correcting and extending the help mechanism and removing the annoying behaviours. A list of all usability issues, fault reports and suggestions for improvement is given in Appendix 3, together with the work proposed in updating the tool.

The tool will be available for distribution to students (those who responded to the questionnaire) in time for their revision. It will be accompanied by a second (shorter) questionnaire aimed at eliciting usability issues and fault reports.

References

Thomas, P.G., Waugh, K, Smith, N. Using Patterns in the Automatic Marking of ER-Diagrams. In Proceedings of ITiCSE '06, June, **2006**, Bologna, Italy, 403-413.

Thomas, P.G., Waugh, K, Smith, N. Experiments in the Automatic Marking of ER-Diagrams. In Proceedings of ITiCSE '05, June, **2005**, Lisbon, Portugal, 158-162.

Appendix 1 M358 ER Data Modelling Revision Tool – Summary of Responses

Usability and Usefulness Questionnaire

The tool was distributed to 80 students who requested it. 27 questionnaires and 1 report were returned.

Usability

This section asks your opinion of how easy you found the tool to use.

(a) Did you have any problems downloading and running the tool? If so, what were they?

No Problems	Problems	No response
25	3	0

(b) How long did it take you to feel comfortable using the tool?

Time (mins)	5	10	15	Longer than 15	No response
No	6	12	4	5 (?, 30, 45, 30, 30)	1

Average: 13.3 mins; median 10 mins

(c) Was it necessary to refer to the help menu for guidance on using the tool? If so, for what purpose did you need the help?

Referred to help	Did not use help	No response
17	9	2

(d) Did you find the drawing tool component easy to use? Did you have any specific difficulties with it (if so, please describe them)?

Easy to use	Not easy to use	No response
21	3	4

(e) What improvements to the drawing tool component would you recommend?

Suggested Improvement	Number of times suggested	Accepted? (Yes/No)
Replace Finished by Exit	1	Yes
Stop getting unwanted boxes	9	Yes
Include a select option which does not create diagram elements.	1	Yes
Add how to obtain crowsfeet and blobs to help.	1	Yes
Tool requires too much precision in selecting	5	Yes

links		
Delete button does not function properly.	1	Yes
Fix bug whereby selecting one box and moving, moves a different box.	1	Yes
Fix bug whereby the name of a link does not move with the link.	8	Yes
Bug in feedback (tool says exact match when two relationships differ).	1	Yes
Want to be able to line boxes up and snap to a grid.	3	Yes
The 'blobs' were not solid round figures.	1	Yes
Pop-up the properties window when creating an element.	2	Yes
No need for both the Mark Diagram and the Show Solution.	1	No
Mention that the shape of the cursor changes when performing different tasks.	1	Yes
The tool should deselect itself after every operation.	1	Yes
Add keyboard shortcuts.	1	Yes
Tools/Options causes the application to close down.	1	Yes
Tools/Show Sim has no obvious purpose (nor does Cliché).	2	No
Undo does not operate reliably.	1	Yes
Print option did not work.	2	Yes
Add an option to list all links and select one for editing.	1	No
Want the ability to format the text (to make it larger)	1	Yes
Implement the keyboard delete key.	4	Yes
Not easy to move links.	1	Yes
Not easy to read the link names when they overlap on the screen.	1	No
Not easy to draw self links.	1	Yes
Methods for selecting boxes and links inconsistent.	1	Yes

(f) What improvements to the usability of the revision tool as a whole would you recommend?

Suggested Improvement	Number of times suggested	Accepted? (Yes/No)
Enable degree of relationship and participation constraints to be added.	1	Already in tool
Ability to copy diagram into Word.	3	Yes
Don't allow the movement of the dividing bar to avoid names becoming disassociated with the elements.	2	Yes
Use right-click to enable a box to be renamed.	1	No
Disallow the editing of a box while in link mode.	1	Yes
Remove box edit points when in link mode.	1	Yes
Make the whole of the box area available for selection.	1	No
Remove highlighting of text when new link is created and make the new link the current selection.	1	Yes
Clear the highlighted question when Show Solution removed.	1	Yes
More detailed feedback with respect to incorrect answers would be useful.	1	Yes
Difficult to get straight lines was a bit annoying.	3	Yes
Improve and correct the instructions in the help facility.	3	Yes
Want the ability to mark the diagram without having to show the solution.	5	Yes
Name the panes.	1	Yes
All tool bars should be located above the panes (not below).	3	Yes
Want the ability to move groups of elements together.	2	Yes
More examples.	1	No

Usefulness

(g) The tool contains 10 examples for users to practice on. How many of the examples did you attempt?

No attempted	1	2	3	4	5	6	7	8	9	10	No response
No of users	5	5	5	1	0	4	3	0	0	4	1

Average no attempted: 4.4

(h) If you attempted only a few of the examples, was it because (tick all that apply):

Reason	Number Agreeing
You were just interested in seeing what the tool could do.	12
You had completed enough examples to be satisfied that your understanding of ER data modelling was adequate.	12
The tool was too difficult or took too long to use. (Difficult / Too long / Both)	2
The tool was not helpful in your studies.	0
The feedback from the tool was too difficult to understand.	0
The feedback from the tool was not detailed enough.	1
Other reason (please specify). Insufficient time.	7

Responses: 19. No response: 9.

(i) If you attempted most of the examples, did you feel (tick all that apply):

Reason	Number Agreeing
The tool helped you to understand ER data modelling?	13
The feedback was reasonably easy to follow?	13
The questions were demanding enough?	14
The feedback from the tool fitted with the way you were taught about ER diagrams in the course?	11
The tool helped you understand a given ER diagram?	14
The tool helped you to produce an ER diagram from a statement of requirements?	15
The tool helped you recognise mistakes when drawing an ER diagram?	15

Responses: 16; No response: 12.

(j) In general, was the tool helpful in your studies?

Yes: 27 (6 of whom said definitely/very), No: 0, No response: 1

(k) What improvements to the tool would you like to see?

See Appendix 3.

(l) Would you recommend the tool to other students?

Yes: 27 (6 of whom said definitely), No: 0, No response: 1

(m) Do you have any other comments you would like to make?

See main body of report.

Appendix 2 Exerciser usability, bugs and suggestions report July 2006

No	Issue description	Type of issue (error/suggest)	Action/Comment	Implemented
1	Tool bars should be above or to the side of the drawing window.	Suggestion	The tool bars can be moved as separate entities and, in particular, can be moved to top or side of window. Not mentioned in help. Update help file.	Already implemented. Help updated
2	Selection of Mark Diagram when feedback window open should be prohibited.	Bug	Caused a run-time error.	Fixed
3	Mark Diagram only works if Show Solution selected.	Bug	Mark Diagram should be selectable whether or not Show Solution is selected.	Fixed
4	Tool shuts down when run-time error occurs without informing the user.	Design error	All exceptions should be reported to the user.	Fixed
5	No instructions (in help) about how to create link adornments. No information about right-clicking.	Help fault	Update help file	Fixed
6	No instructions about how to 'bend' lines.	Help fault	Update help file.	Fixed
7	No instructions about how to add a self link.	Help fault	Update help file. Multiple self relationships implemented.	Fixed
8	Difficult to select links.	Suggestion	Increase tolerance on selection area of link. Allow perimeter of box to be part of the selection area.	Fixed
9	Changes in cursor not explained.	Help fault	Update help file.	Fixed
10	Accidental production of boxes.	Design Error	The use of a left-click to create a standard sized box caused too many boxes to be produced by accident. This is a 'convenience' function. Change to right-click.	Fixed in design change D1

11	Undo unpredictable; often went back 2 steps.	Bug	Several problems due to complex interactions.	Fixed
12	The name field of a link does not move when the link is moved.	Bug	Minor fault.	Fixed
13	Delete does not always work correctly.	Bug	Possibly related to selection.	Fixed in design change D1
14	Problems with resizing a box. Not all edit points work and tool seems to default to lower right hand edit point.	Bug	Minor fault.	Fixed
15	Help needs to make it clear that the box button needs to be pressed before a box can be selected.	Suggestion	Update help file in line with design change D1.	Accepted
16	For compatibility with other tools use the 'plus' symbol to indicate that an element can be moved.	Suggestion	There is a convention for cursor icons used in the tool. Update help file to explain the convention	Help updated
17	Delete key should be alternative to Delete button.	Suggestion	Requested numerous times.	Implemented
18	Names become detached from elements (especially when moving boundaries).	Bug	A difficult fault to rectify. An inelegant solution found.	Fixed
19	Names of links between the same boxes too close.	Help fault	Link names can be moved independently of the links. Not mentioned in help. Update help file.	Help updated
20	Annoying to have to switch between box and link buttons.	Suggestion	No action envisaged as new design D1 alters the interface.	No action
21	Do not allow editing of box properties or box name when a link is selected (and vice versa).	Bug	Agreed. Minor fault.	Fixed
22	Remove box edit points when selecting link.	Bug	Agreed. Minor fault.	Fixed
23	Remove edit points from link when creating a new link and make new link the selected link.	Bug	Agreed. Minor fault.	Fixed

24	Closed blob not fully filled.	Bug	Requires anti-aliasing, or some other 'fudge'.	Partial fix
25	The Close button on the feedback window does not work when window is maximised.	?	Cannot replicate this 'fault'.	No action
26	Feedback not working properly – score not correctly displayed.	Bug in feedback	Agreed. Minor fault.	Fixed
27	Feedback incorrect – says exact match when there is a difference in participation criteria.	Bug in marker	Agreed. Minor fault.	Fixed

Further suggestions

No	Issue description	Type of issue (error/suggest)	Action/Comment	Implemented
1	Enable link adornments to be added.	Suggestion	This can be done. Instructions not clear.	Rewritten instructions
2	Allow move/resize boxes without having to click on box or link.	Suggestion	Needs redesign.	Done
3	Prevent accidental construction of boxes.	Suggestion	Change to right-click	Done
4	Have a select option to avoid accidental construction of boxes.	Suggestion	Select option useful for multiple selections, too.	Done. Multiple selection implemented
5	Improve help to show how to add link adornments	Bug	Inadequate help.	Help updated
6	Do not allow direct editing of box names.	Suggestion	A short-cut that will be retained (otherwise requires a design change).	No action
7	Make whole of box area available when creating a new link.	Suggestion	A result of using a TextField for box name and allowing it to be editable. Maybe difficult to implement. Requires redesign.	No action
8	Include a facility to align boxes and snap to grid.	Suggestion	Alignment of boxes can be done, but snap to grid requires design change.	Done (alignment only)
9	Pop-up link properties window when link is	Suggestion	Helpful suggestion that reduces mouse clicks.	Done

	created		Design change.	
10	Improve help to indicate the meaning of the cursor icon changes.	Suggestion	Inadequate help.	Help updated
11	Don't leave box and link buttons selected once action has been carried out.	Suggestion	Design change	Done
12	Change to Manhattan routing for links.	Suggestion	Design change. Unlikely to be implemented in the near future.	No action
13	Add keyboard short-cuts	Requirement	Essential for SENDA compatibility.	TO DO
14	Include new menu item to display all links to allow selection of a link.	Suggestion	Suggested to overcome difficulty in selecting links. Other mechanisms exist which are more likely to be implemented.	No action
15	Update and correct help.	Requirement	Essential.	Help updated
16	Implement multiple selection for moving purposes.	Suggestion	Helpful improvement.	Done
17	Include a facility to enable diagram to be exported into Word.	Requirement	Needed for TMA purposes.	Done
18	Implement Print option	Requirement	Required.	Done
19	Enable text (names) to be formatted (in particular to make larger and bold).	Suggestion	Good usability suggestion. Perhaps have an Option to set size and bold/italic properties.	Done

Proposed design changes

D1 To deal with the problem of accidental box creation (issue 10), reducing the need to switch between box and link mode (issue 20) and improve selection mechanism (suggestions 2 and 4) a new toggle button named Select Item will be introduced so that element selection, movement, deletion and property changing, and resizing of boxes, can only occur when this button is selected. Furthermore, new, standard sized boxes will be created by a right-click rather than a left-click.