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Consultation of Misconceptions Representations by Students in Education-Related Courses

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Abstract. This paper considers learner misconceptions information which is presented to the learner in an open learner model. We suggest that specific information about misconceptions may be of benefit to the learner, to help them reflect on their knowledge and understanding. We investigate acceptance of their misconceptions presented as animations and step-by-step text descriptions by two groups of users: trainee teachers, and computer engineering students taking an educational technology course. Our study revealed mixed findings.

Keywords. Misconceptions information, animation and text, open learner model

Introduction

Many students view computer programming as one of the most difficult subjects to be learnt [1, 2, 3]. Some instructors also find it a challenging task to teach programming languages, because in order to develop a system, the learner not only has to master the programming code, but also needs to have the ability to interpret the flow of data or instruction placed in computer memory [4]. While learning a programming language, learners may create their own conceptual model to interpret the execution of the programming code. This conceptual model may vary for each learner, and may be different from the (correct) domain knowledge. For some novice learners, this inaccurate conceptual model could lead them to a misunderstanding of the domain concept, which might lead to misconceptions.

Several research studies have identified learners' programming misconceptions, for example Object-Oriented Programming [3], BASIC programming [4], Java programming [5]; and misconceptions have been identified in a variety of subjects not only for learners, but also for parents helping their children [6], teachers [7, 8], and adults in general [9]. Much of the research focuses on methods and approaches to identify misconceptions, to be used by teachers as a guide to improve their teaching strategies and learning materials [10, 11, 12]. Such information about misconceptions may also be useful to students.

Open learner models (OLM) allow learners to explore their learner model, as it is externalised to them. Opening the learner model to the learner has been argued to give to the learner, more control and responsibility for their learning process [13]; to help

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them understand their knowledge, see whether they have misconceptions, reflect on what they have learnt and take further action towards solving their problems [14]; and can improve learner performance and self confidence [15].

Previous work has identified that students will use an open learner model to investigate simple descriptions of their misconceptions [16]. In this paper, we investigate whether more detailed, step-by-step explanations of their misconceptions might be beneficial to learners, if it was revealed to them. We explore these questions with reference to two diverse groups, but that have in common an interest in education and computing.

1. Presenting Misconceptions in an Open Learner Model

OLMs can provide information to the learner about their understanding in detailed forms such as concept maps, pre-requisite structures or hierarchical tree structures [17], or can offer simpler overview information [15]. OLMlets is a domain-independent open learner model that builds a simple numerical model of an individual's knowledge level and likelihood of specific misconceptions, weighted according to their most recent responses to multiple-choice questions input by the course instructor, on a set of topics [18]. Because of the simplicity of the modelling, OLMlets displays the learner model to the learner in simple formats, aiming to encourage reflection by showing the user their level of knowledge and brief descriptions of any misconceptions they are inferred to hold. (Misconceptions are defined by the course instructor.)

Figure 1 shows the OLMlets skill meters indicating knowledge level in the first block of colour in the second set of skill meters; the extent of misconceptions in a topic in the second block of colour (including a link to a statement of any misconceptions held); and generally problematic knowledge (not related to specific misconceptions) in the third block of colour. Learners can also compare their knowledge level with the current knowledge expected by the instructor, to review whether they are meeting the present expectations for a course (indicated by the two sets of skill meters for the two topics shown in Figure 1). Learners found the brief text statements about misconceptions useful, with the majority of users accessing these descriptions [16].

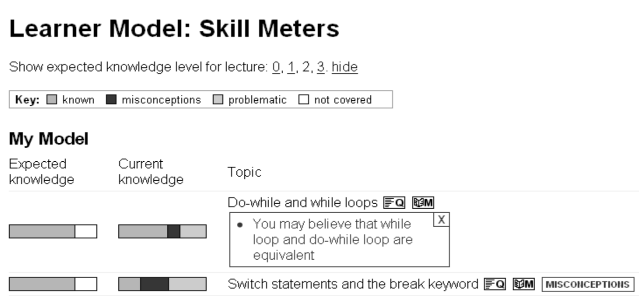

Figure 1. The OLMlets open learner model [18].

V.Dimitrova, R. Mizoguchi, B. du Boulay & A. Graesser (eds).
Artificial Intelligence in Education, IOS Press, Amsterdam, 2009, 565-572.

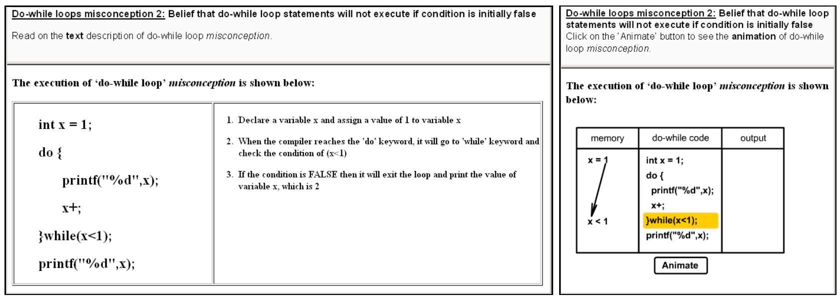

Figure 2. Animation and text description of misconceptions in AniMis.

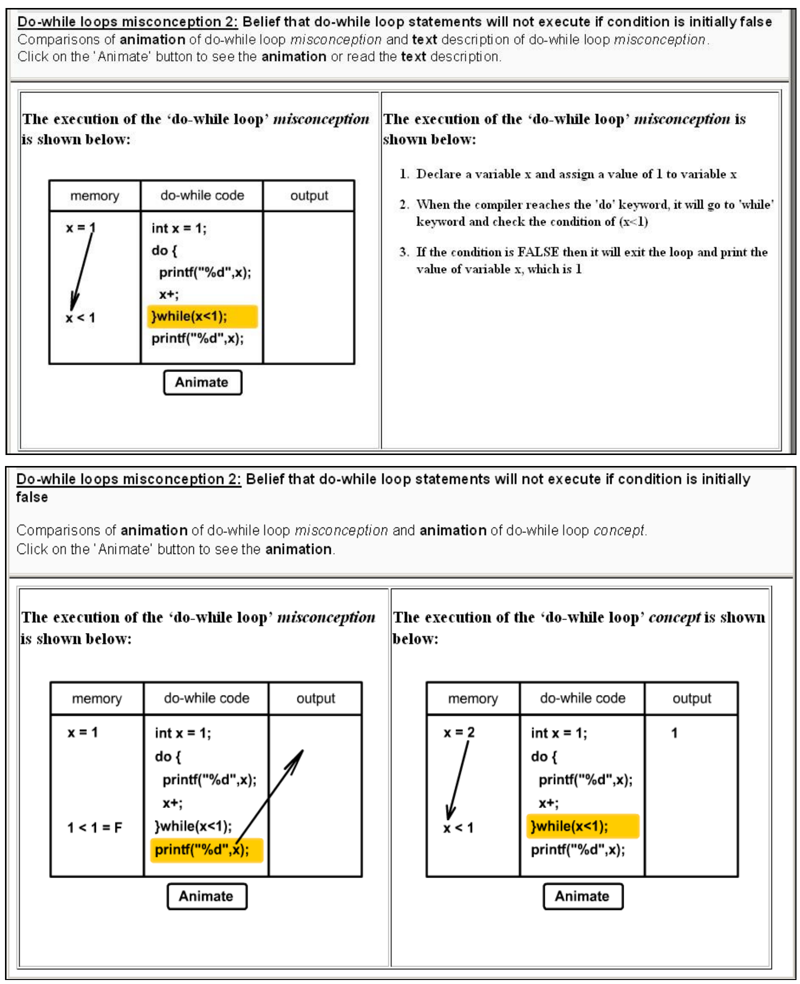

Figure 3. Comparison of misconceptions information in AniMis.

V.Dimitrova, R. Mizoguchi, B. du Boulay & A. Graesser (eds).
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AniMis is built on top of OLMlets. When users click on a misconceptions link in OLMLets (Figure 1) rather than the brief text, they are taken to AniMis which provides more detailed misconceptions information in step-by-step text, or using animation. Figure 2 (left) shows the code alongside the explanation of the student's misconception. Figure 2 (right) shows an excerpt from an animation, which simulates the steps of execution of the code and how the data is passed from the computer memory to the output screen, highlighting the code at each step. The learner's task is to check the misconception information in text and/or animation format as best suits their learning preference, to help them identify whether they do indeed hold a misconception, in order that they can work towards clarifying their difficulties and amending their 'incorrect concepts'.

In addition to viewing animations or text descriptions of misconceptions, AniMis offers four types of comparison: a) animations and text descriptions of misconceptions; b) animations of misconceptions and concepts; c) text descriptions of misconceptions and concepts; and d) animations and text descriptions of concepts. The animations of concepts aim to help learners visualise the execution process [19]. Figure 3 (upper) illustrates the comparison between animation and text description of misconceptions; Figure 3 (lower*)* shows the comparison of animations of misconception and concept.

2. Learners' Investigations of their Misconceptions

As stated above, previous work shows learners have an interest in their misconceptions when viewing brief statements of their misconceptions in OLMlets [16] and consideration of misconceptions has also been recommended in other computer-assisted learning contexts [20]. This study investigates the extent to which learners in different types of education-related courses, in different educational cultures, consult information about their own misconceptions when this is presented in detail.

2.1. Participants, Materials and Methods

Participants comprised two groups of students. The first group of learners were 9 final year undergraduate trainee teachers (TT) majoring in Information Technology at Universiti Pendidikan Sultan Idris, Malaysia, who were learning C Programming as future teachers[2]; and the second group were 10 Masters (M) students in Electronic, Electrical and Computer Engineering, University of Birmingham, UK, taking degrees in Human-Centred Systems (MSc) and Computer Interactive Systems (MEng). The second group were taking an Educational Technology course focusing on educational issues and system design, and had previously completed a C programming course.

The study was undertaken in laboratory sessions as part of the respective courses. The first group had two lab sessions, lasting approximately one hour each. A demonstration had shown how to use both OLMlets and AniMis, for familiarisation, and the trainees were also given approximately a week to explore the systems on their own before the first session. The second group took part in a single lab session lasting

[2] It should be noted that the trainee teacher group had 15 students (see [21] for further information about the TT group). We here consider the data for the 9 who inspected the information about their misconceptions.

approximately three hours (including breaks). Students were familiar with OLMlets, and a demonstration of AniMis was given before the session commenced.

Students in each course were instructed to use OLMlets, answering questions and exploring their inferred knowledge levels of 'Do-while loops' and 'Switch statements' as required, and inspecting their misconceptions in text or animation in AniMis (accessed from the OLMlets 'misconceptions' links (Figure 1)); and make comparisons, as suited their learning (Figures 2 and 3). All interactions were logged. A questionnaire with fixed response options on a five point scale (strongly disagree, disagree, neutral, agree, strongly agree), was completed at the end of the lab sessions. Responses of strongly agree and agree, and strongly disagree and disagree, were combined for analysis.

2.2. Results

Table 1 shows the values for each group, for the number of questions attempted, and for user inspection of their knowledge levels in OLMlets. Learner model inspections were frequent. The trainee teachers most commonly accessed their learner models in OLMlets after every two questions, whereas the Masters students tended to view their knowledge levels after each question they attempted.

Table 1. Use of OLMlets.

	Mean	**Median**	**Range**
Questions attempted (TT)	48.9	54	13-60
Knowledge level viewings (TT)	24.1	23	1-53
Questions attempted (M)	17.5	18	3-35
Knowledge level viewings (M)	17.4	14.5	6-38

Table 2. Use of AniMis.

	TT (n=9)	**M (n=10)**
Misconceptions	9 users	10 users
Concepts	3 users	8 users

Table 3. Questionnaire responses: utility of AniMis.

	Disagree		**Neutral**		**Agree**	
	TT	**M**	**TT**	**M**	**TT**	**M**
Understood the animations of misconceptions	1	0	5	2	3	8
Understood the text descriptions of misconceptions	0	1	5	4	4	5
Understood the animations of the concepts	0	0	5	2	4	8
Understood the text descriptions of the concepts	0	2	6	1	3	7
The animations of misconceptions were useful	1	1	2	4	6	5
The text descriptions of misconceptions were useful	1	1	3	4	5	5
The animations of concepts were useful	0	0	3	3	6	7
The text descriptions of concepts were useful	1	2	3	1	5	7

Users in each group held between one and three misconceptions (TT median=3; M median=2). Table 2 shows use of AniMis to view concept and misconceptions information (in either animation format or text explanation). All Masters students viewed the information about their misconceptions; and most of the Masters students viewed the related concepts (either separately or in one of the comparison views). As stated above, there were 15 trainee teachers who had misconceptions, but only 9 viewed the information about their misconceptions. Of these 9, 3 also viewed information about the corresponding (correct) concept(s).

Table 3 shows questionnaire responses, broken down into the student groups with reference to the 10 Masters students and 9 trainee teachers who accessed their misconception descriptions.

Most of the Masters students claimed to understand the misconceptions information when this was viewed as an animation, but only half understood the text. However, all but one stated that they understood at least one of the two methods of presentation of their misconceptions, and there was only one negative response (for text). Four of the 9 trainee teachers agreed that they understood the misconceptions text; and 3, the animations. Five understood at least one representation format. One student stated that they did not understand the animation. The figures were similar for animations and text descriptions of the (correct) domain concepts, with 9 of the Masters students and 6 of the trainee teachers understanding at least one representation. Half the Masters students found each of the misconceptions representations useful for their learning, with 7 of the 10 finding at least one representation useful. Eight found the concept information useful (with 7 agreeing that text, and 7 agreeing that animations were helpful). Two thirds (6) of the trainee teachers found the animations of misconceptions useful, 5 considered the text descriptions helpful; 6 found the animations of concepts useful and 5, the text descriptions of concepts.

2.3. Discussion

We are not attempting to make a direct comparison of the extent of use of the two groups of learners, as each spent different lengths of time and a different number of sessions interacting. Therefore the difference in the number of questions attempted between the groups is not considered important here. This has been shown in order to demonstrate the frequency of model viewing in OLMlets, for knowledge level: usually after every attempt at a question by Masters students; after every second question by trainee teachers. This provides the context within which to discuss the accesses to the AniMis step-by-step misconceptions information from within the OLMlets knowledge overviews.

All Masters students viewed their misconceptions data, whereas not all trainee teachers did so. The latter is of concern, since if those intending to teach others, hold misconceptions themselves, there is a likelihood that they will pass these on to their students. This is not a new problem, or a problem specific to those aiming to teach programming and IT topics. For example, misconceptions of trainee teachers have also been considered in physics [22], biology [12], chemistry [11], and mathematics [7]. Only 9 of the 15 trainees actually reviewed their misconceptions in C programming, despite their need to prepare lessons in the subject. To some extent, this may be because they considered the information about their misconceptions to be less useful than did the Masters students. However, of the 9 users from the trainee teacher group who did inspect the information about their misconceptions, more students claimed to find the information useful, than to understand it. Thus they seemed to be able to make use of the information to identify the existence of a problem, even if they were not able to directly resolve it – note that most of the trainee teachers did not view the information about the correct concepts, to compare to the misconceptions. However, the fact that they now had knowledge of their difficulties, was perceived positively.

This was likely because they were then able to identify where to concentrate their study in preparation for their teaching practice.

The Masters students, using OLMlets in the context of an Educational Technology course with a strong focus on designing educational systems, had greater understanding of the misconceptions information (in at least one form), but not all considered it as useful (though there was only one negative response). However, learners did perceive the utility of the concept descriptions to be higher.

There may, of course, be many reasons for the differences between our groups: cultural, language knowledge, educational context, teaching approaches and differences between the purposes of studying education-related courses (to teach in a school, or in relation to computer engineering). Therefore we do not aim to try to account for these differences: further work would be required, and larger group sizes would be needed. However, at this stage we can suggest that some learners do appear to find detailed information about their misconceptions helpful. Further investigation would be useful to see whether the same kinds of usage levels might be obtained as for simple misconceptions statements in a variety of subjects [16], not just education-related ones; and would be in line with recommendations to include discussion of misconceptions in computer-assisted learning to promote conceptual change [20].

We have not been concerned specifically with whether students prefer to use the step-by-step animations or text explanations, though some differences were observed. We suggest that both can be useful – to the same and to different students. The question remains, however, of how to reach those students who struggle to work with their misconceptions, as it is not always easy to change misconceptions held by learners [23]. We will investigate additional support and scaffolding for such students. Helping learners to recognise learning difficulties and discover the existence and content of any misconceptions at the early stages, where describing the misconceptions information may be considered too complex, can be compared against the potential for simpler descriptions of misconceptions to support learning as already demonstrated [16].

3. Summary

This paper has suggested possibilities for presenting detailed information about misconceptions in the form of animation and text descriptions, to assist learners in recognising any learning difficulties, and reconstructing correct concepts. The results of this study support previous findings for simple misconceptions statements, for some of the participants: that learners have sufficient interest to investigate their misconceptions and may find this process helpful to their learning. However, this did not hold true in all cases. Further work is needed to investigate these differences, and to determine whether simpler misconceptions statements may be sufficient for those who find them easier to work with, or whether it may be more helpful to try to work with misconceptions in more detail, generally.

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