

# UMPTEEN: Named and Anonymous Learner Model Access for Instructors and Peers

**Susan Bull, Andrew Mabbott and Abdallatif S. Abu Issa.** *Electronic, Electrical and Computer Engineering, University of Birmingham, Edgbaston, Birmingham B15 2TT, U.K.*

*s.bull@bham.ac.uk*

*http://www.eee.bham.ac.uk/bull*

**Abstract.** Recently, opening the learner model to the learner it represents has become more common in adaptive learning environments. There have also been systems that allow instructors access to the learner models of their students, and a few examples of systems which open the learner model to the student's peers. However, little investigation has taken place into students' attitudes to viewing the learner models of others, and their likelihood of making their own models available for inspection by others. The UMPTEEN approach was developed in order to investigate students' views about opening their learner model more widely, and to observe how they use their own and peer models. This paper presents the first results from a lab-based study of an open learner model that can be optionally opened to others, in named and/or anonymous form. Results suggest that there are sufficient students interested in viewing peer models, and sufficient students willing to open their learner models to instructors and peers, to make further studies worthwhile.

**Keywords.** Open learner model, learner reflection, collaborative learning, competitive learning.

## 1. INTRODUCTION

Open learner models are learner models that can be accessed by users, presented in a format that is understandable to the user. The complete model may be accessible, or only partial information (for example, if the full model would be too detailed to be interpretable). Reasons for opening the learner model to the learner modelled vary, but commonly include: supporting navigation in adaptive educational hypermedia with adaptive link annotations (Brusilovsky et al., 2004; Weber & Brusilovsky, 2001); allowing learners greater control over the interaction and their learning by allowing them to directly influence the contents of their learner model (e.g. by editing or adding evidence to it) in intelligent tutoring systems (Bull & McEvoy, 2003; Kay, 1997); and facilitating learner reflection by confronting learners with representations of their understanding in adaptive learning environments, with the aim of promoting self-monitoring and metacognition (Bull & Pain, 1995; Dimitrova, 2003).

Although an open learner model is most commonly opened to the learner that the learner model represents, it can also be made available to other interested parties. This may be instructors - to help them review the evolution of a student's knowledge (Rueda et al., 2003); to help them organise learning groups (Mühlenbrock et al., 1998); or to help them adapt their teaching to better meet the needs of the individual or the group (Grigoriadou et al., 2001; Zapata-Rivera & Greer, 2004). The learner model may be opened to a learner's peers - to stimulate collaboration and peer interaction for co-present peers (Bull & Broady, 1997); or distributed viewing leading to later face-to-face or distributed collaboration (Bull & Nghiem, 2002). Or the learner model may be available to parents - to enable parents to review their child's progress (Zapata-Rivera et al., 2005). However, to date there has been little research into how students might use a learner model that can be opened to other users; whether they find this beneficial; and importantly, the privacy issue of whether they are happy for other users to view their learner model data. We address these questions with the UMPTEEN (User Models for Peers and Teachers for Educational Emulation and

Networking) approach. UMPTEEN users can choose to open their individual learner model to all or selected instructors either anonymously or with their personal identifying details available; and they can choose whether to open their learner model to all or selected peers, again in anonymous or named form. Thus many (or umpteen) learner models will be available to each user in courses where students choose to make their learner models accessible to others. A model summarising the group's understanding, showing how many individuals are at each stage of learning for each of the topics, is also available. When learner models are opened to instructors, this allows instructors to use the open learner models for any of the reasons listed above; and learner models opened to peers allow students to engage in collaborative or competitive learning. The individual may, of course, also view their own learner model, allowing individual reflection separate from, or in combination with collaboration and/or competition.

This paper presents the results of 3 experimental studies of the use of UMPTEEN amongst groups of different sizes in the Electronic, Electrical and Computer Engineering department at the University of Birmingham. This is a first step aimed at identifying whether students are willing in principle, to open their learner model data to others.

## **2. AN OPEN LEARNER MODEL FOR STUDENTS, INSTRUCTORS AND PEERS**

UMPTEEN can be used independently or the approach can be integrated into a larger adaptive system. When used separate from an adaptive learning environment it is intended for use alongside a lecture course. Instructors can input multiple choice questions about their courses through an interface which allows the definition of correct answers, incorrect answers and misconceptions. It also allows images to be uploaded for questions and answers, and limited special characters. UMPTEEN can therefore be used in many courses for which multiple choice questions are appropriate.

As it can be used independently, UMPTEEN does not itself contain domain knowledge, and it does not perform any tutoring or offer adaptive recommendations, as the aim is to encourage students to themselves identify areas of difficulty and then consult lecture slides, lecture notes, external materials, or other users for help or collaborative learning, accordingly. Thus the open learner models of UMPTEEN seek to encourage further work outside the system by confronting learners with their current state of knowledge, prompting them to take responsibility for improving their understanding. UMPTEEN is simply an approach to open learner modelling that allows learners the option of releasing their learner model to other users. As stated above, the approach can be used independently of any particular system to encourage learner autonomy, or it can be incorporated into a learning environment that uses multiple-choice questioning, where additional adaptive support will be available. This paper describes the use of UMPTEEN independently of a learning environment in order to examine whether students are happy to release their learner model to others, and whether they perceive a benefit from this approach, without confounding the results with any benefits perceived from its use within a larger system.

### **2.1 Learner Modelling in UMPTEEN**

UMPTEEN infers learner knowledge and misconceptions according to a student's answers to the multiple choice questions provided by instructors. These questions are presented in a random order, on topics about which the learner has selected to answer questions. UMPTEEN constructs a numerical model of knowledge level that places heavier weighting on the most recent answers, in order to reflect the learner's evolving knowledge at all times. Only the last five responses for each topic contribute to the learner model representations for that topic, with the weighting increasing by 0.3 for each successive answer. In the learner model, knowledge level is represented by a figure between 0 and 1. The closer the representation for a topic is to 1, the higher the learner's knowledge is for that topic, with 1 indicating mastery, and 0 indicating no knowledge. If a learner has not attempted any questions on a topic, no value is recorded in order to distinguish it from lack of knowledge, as no evidence about the learner's knowledge is available. Possible misconceptions that

are defined by the instructor are transferred to a misconceptions library, related to the course for which they were identified. Misconceptions are represented in a similar way to knowledge, with a numerical value between 0 and 1 indicating the probability that the misconception is held. If this score is greater than 0.5 the misconception shows as possibly held. So, for example, 3 out of 4 or 2 out of 2 responses suggesting a misconception would indicate a likely misconception. Greater emphasis is placed on recent answers in the same way as for modelling knowledge.

## 2.2. Opening the UMPTEEN Learner Model

There is a wide range of presentation formats for learner model data. Examples include detailed textual descriptions of the learner model information (e.g. Bull et al., 1995) and complex graphical views of the learner model (e.g. Dimitrova, 2003; Kay, 1997; Mabbott & Bull, 2006), in systems that build detailed learner models. Simple graphical overviews of knowledge level are also used, the most common being skill meters indicating knowledge of the various topics as a series of part-filled bars or 'meters' representing the extent of knowledge of each topic (e.g. Bull et al., 2006; Corbett & Bhatnagar, 1997; Mitrovic & Martin, 2002; Papanikolaou et al., 2003; Weber & Brusilovsky, 2001), which can be used either to externalise parts of complex learner models, or to externalise simpler models where knowledge level only, is modelled. As a first step in research into the question of whether students are willing to open their learner model to others, the open learner model was kept simple, using a skill meter approach to indicate knowledge level combined with textual descriptions of likely misconceptions held by the learner, inferred from the misconceptions library. (Future work can then build on these findings, investigating how learners might use and share more complex models.) Knowledge level is displayed in skill meter form as a series of filled and unfilled stars for each topic or concept, as shown in Figure 1. The number of stars for each topic can be customised by the learner to between 3 and 20, according to the degree of granularity they prefer to view. Where misconceptions exist, these are stated under the topic heading.

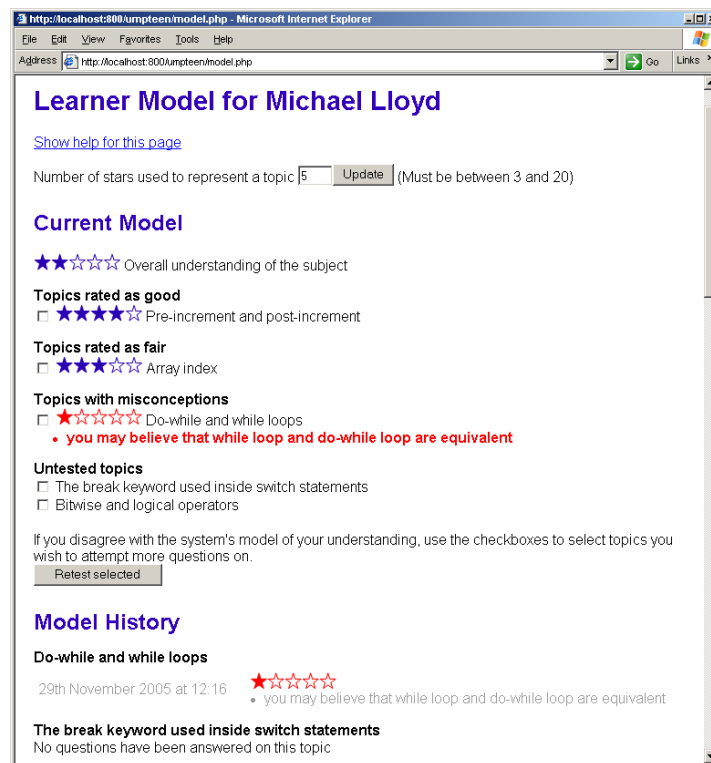
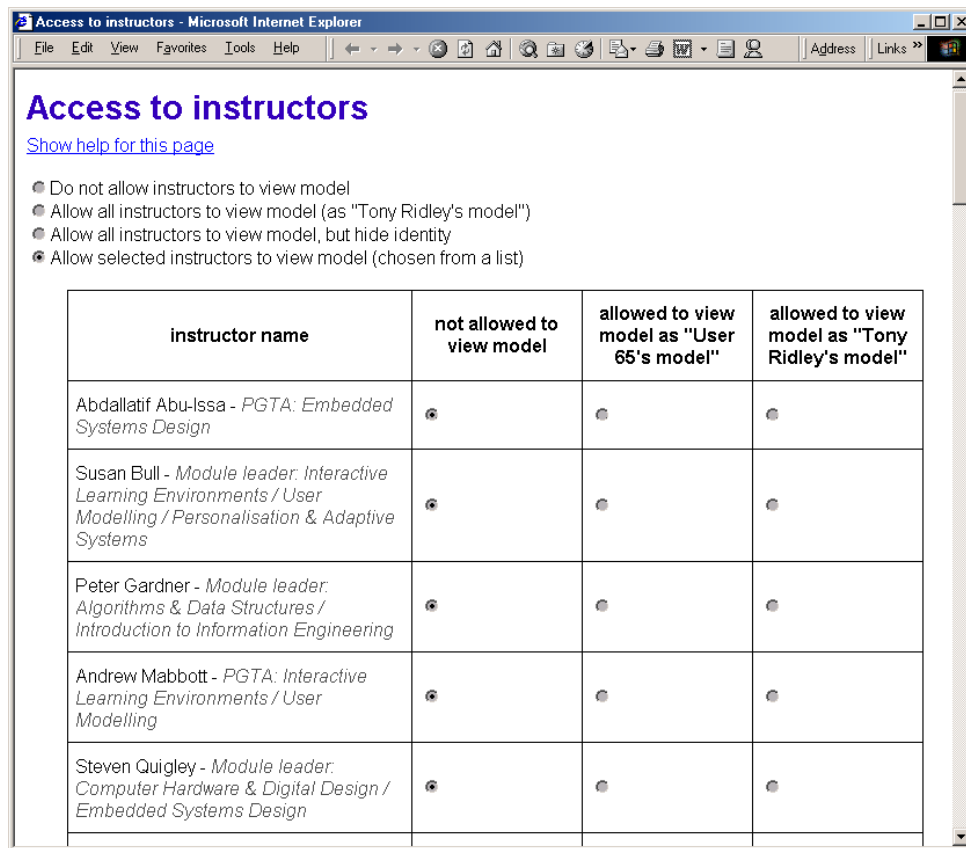


Figure 1. Skill meters and misconceptions descriptions

If learners disagree with any of the representations in their learner model, they can request a quick test to try to persuade the system that their view of their knowledge is more accurate than that modelled by the system - for example, they may have had an additional lecture since last using UMPTEEN, and therefore improved their understanding. This feature allows students to more quickly update their learner model contents than would be achieved by completing exercises in the standard interaction, as proposed by Mabbott & Bull (2006). If a student's responses to the test match their own viewpoint about their knowledge, the learner model is updated accordingly. However, if the model was correct, it remains unchanged. Historical model data is also available, to enable students to review their progress over time, as suggested useful for open learner models in systems where historical model data is maintained (Bull et al., 1995). This historical data is saved on logout, reflecting the learner's knowledge at the end of each interaction.

Students can opt to open their learner model to their peers and/or their instructors, choosing for each individual whether to release their model anonymously or with their personal details available. This is illustrated (for releasing the model to instructors) in Figure 2. Instructors' names are listed followed by the courses they teach, and postgraduate teaching assistants (PGTA) are listed followed by the courses they help with. In ongoing work where students are using the UMPTEEN approach alongside several courses, only those instructors relevant to a particular course are listed for selection for that course. Here we were interested simply in how widely students would open their learner models to instructors in the experimental setting. For selecting peers to release one's learner model to, the names of all students who have registered for the same course in UMPTEEN, are listed. Where a student is registered for more than one course in UMPTEEN, they choose for each course separately, how they wish to release their learner model (if at all).



**Figure 2.** Opening the learner model to others

Instructors and peers can access the learner models of other users by clicking on the person's name in a list, or the model number (for models released anonymously). Models are then displayed in the

same format as they are viewed by the individual they represent, minus the 'retest selected' button and checkboxes. For anonymous models, the user's name is replaced by the model number. Note that some users may access an individual's learner model anonymously, while others have named access to the same model, and yet others have no access. Students can also view group data from all learner models, showing the distribution of current knowledge and/or problems across all users, as shown in Figure 3.

The screenshot shows a web browser window titled 'http://localhost:800/umpteen/group.php - Microsoft Internet Explorer'. The address bar shows 'http://localhost:800/umpteen/group.php'. The main content area is titled 'Group Model' and includes a link 'Show help for this page'. Below the title is a table with the following data:

Topic	Users attempting exercises on topic	Users with good knowledge	Users with fair knowledge	Users with weak knowledge	Users with misconceptions
Do-while and while loops	28	9 (32%)	10 (35%)	9 (32%)	2 (7%)
The break keyword used inside switch statements	24	3 (12%)	5 (20%)	16 (66%)	10 (41%)
Bitwise and logical operators	21	1 (4%)	7 (33%)	13 (61%)	1 (4%)
Pre-increment and post-increment	16	4 (25%)	5 (31%)	7 (43%)	5 (31%)
Array index	19	9 (47%)	5 (26%)	5 (26%)	3 (15%)

Figure 3. The group model

### 3. STUDIES WITH UMPTEEN

For this initial stage of research into students' use of learner models that can be opened to others, we focus on whether learners choose to open their learner model to instructors (academics and postgraduate teaching assistants) and peers, and their reasons for doing so; and whether they choose to open their learner model anonymously or with their personal details available. This is a crucial first step if considering privacy issues relating to consent for revealing individual personal data. We also investigate whether students choose to view the learner models of their peers, and how useful they believe this to be for their learning. The aim at this stage, therefore, was an experimental study to observe learner behaviour in order to gauge the potential of learner models that can be optionally opened to others. While this does not reveal the patterns of opening the model over time, in an authentic learning context, it does address the critical first question of whether learners are prepared to reveal information about their understanding to other users.

#### 3.1 Participants and Methodology

In the studies reported here, UMPTEEN was used independently of any adaptive learning environment. Such independent use of UMPTEEN aims to encourage learners to undertake appropriate work outside the system, once they have identified their areas of greatest weakness - i.e. UMPTEEN does not itself tutor students in their problematic areas. It is therefore not expected that learners should improve their understanding during an interaction with UMPTEEN (unless, for example, identification of a misconception leads a student to realise their problem), and so pre-tests and post-tests were not administered. For issues relating to viewing and opening the learner model according to ability, participants' levels of knowledge were determined from their learner models.

Three experimental studies were undertaken in the Electronic, Electrical and Computer Engineering department at the University of Birmingham, U.K., with the aim of discovering the potential for UMPTEEN amongst experienced students (i.e. students in the later stages of their academic experience). The three groups were of different sizes, in order to investigate usage in different types of group within this population:

1. A small group of 12 volunteers: MSc students who knew each other well, who were taking MSc degrees in Human Centred Systems; Multimedia Computer Systems; Electronic and Computer Engineering; Communications Engineering. The aim was to investigate whether, amongst a small group of learners who knew each other quite well, users would be willing to open their learner models to each other - and if so, whether they would do so with their names attached or anonymously.
2. A medium-sized group of 26 3<sup>rd</sup> years (some in their final year of a 3 year BEng degree; some in the third year of a 4 year MEng degree), taking degrees in Computer Interactive Systems or Computer Systems Engineering. The aim was to observe how the learner models were used in a medium-sized group. In addition to whether students open their learner models to all or selected individuals, we here also consider whether students prefer to open their learner model to their friends, to those they consider to be better or worse at the subject than themselves, etc. (i.e. amongst a larger group it is possible to ask questions that could not be investigated with the smaller group who knew each other well).
3. A large group comprising 50 MSc students taking the same MSc degrees as those in the small group, described above. The aim was to determine whether and how students would open their learner models to other users in a larger group. The same issues were investigated as for the medium-sized group.

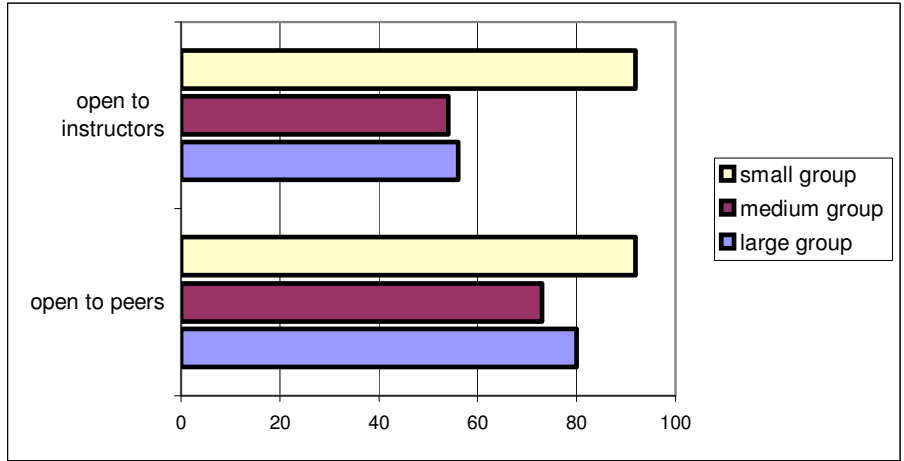
The three studies used C programming questions, as students in the department at both undergraduate and masters level learn C programming. The studies took place in one of the department's computer laboratories, where students had up to two hours to interact with UMPTEEN. Most of those in the two larger groups used it for at least an hour; and for a shorter period in the small group. Students were asked to attempt questions in areas that they considered they knew well, in addition to areas in which they thought they might have problems. They were not otherwise prescribed how to use the UMPTEEN learner models, as the aim was to investigate whether they would choose to view the learner models of others, and whether they would choose to allow others to access their own model. Instructors and postgraduate teaching assistants were available to answer questions about how to use UMPTEEN. Help pages for using UMPTEEN were also available for consultation.

UMPTEEN logs all actions. Information about whether and how students opened their learner model to others, was drawn from the logs.

Questionnaires were administered at the end of the lab sessions with the medium-sized and large groups. Questionnaire statements required responses on a 5 point scale, ranging from 'strongly agree' to 'strongly disagree'. In the analysis below, we consider responses of 'strongly agree' and 'agree' to indicate that learners found the particular aspect of UMPTEEN useful. Neutral responses (the mid-point of the scale), and negative responses (disagree and strongly disagree), were ignored. Students were also asked to expand on their fixed-choice responses in open-ended format. Questionnaires were returned from all 26 students in the medium-sized group, and 46 of the 50 students in the large group.

### **3.2 Results**

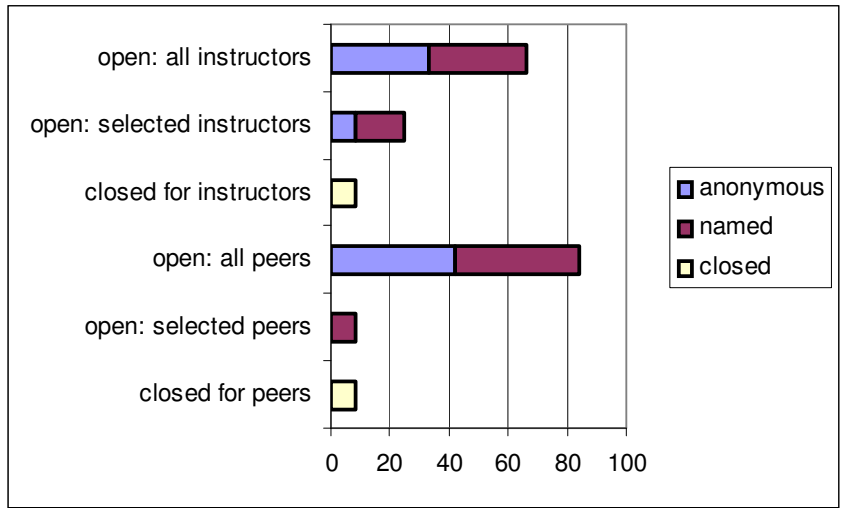
Taken from the system logs, Figure 4 shows the percentage of students in each group (small - 12 students; medium-sized - 26 students; large - 50 students), who chose to open their learner model to instructors and peers.



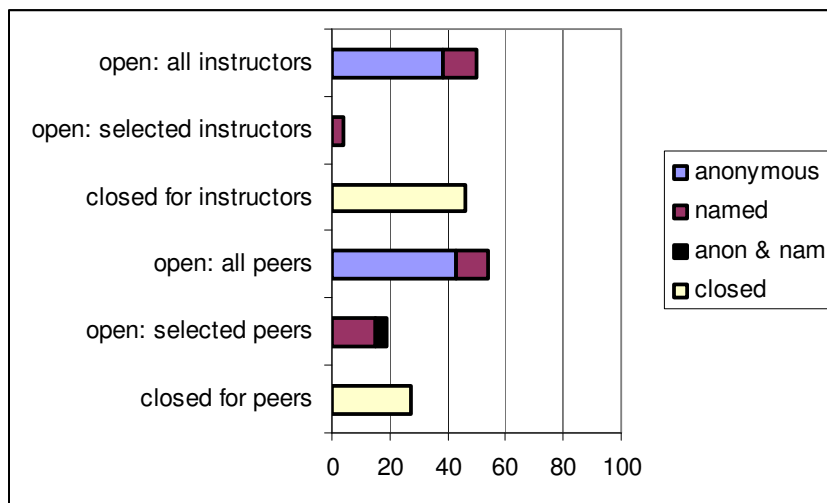
**Figure 4.** Opening the learner model to instructors and peers in a small (12), medium-sized (26) and large (50) group

In the small group, nearly all students (92%) opened their learner model to both instructors and peers. In the other two groups the numbers were lower, with 54% in the medium-sized group, and 56% in the large group opening their learner model to their instructors; and 73% of the medium-sized group and 80% of the large group opening it to their peers.

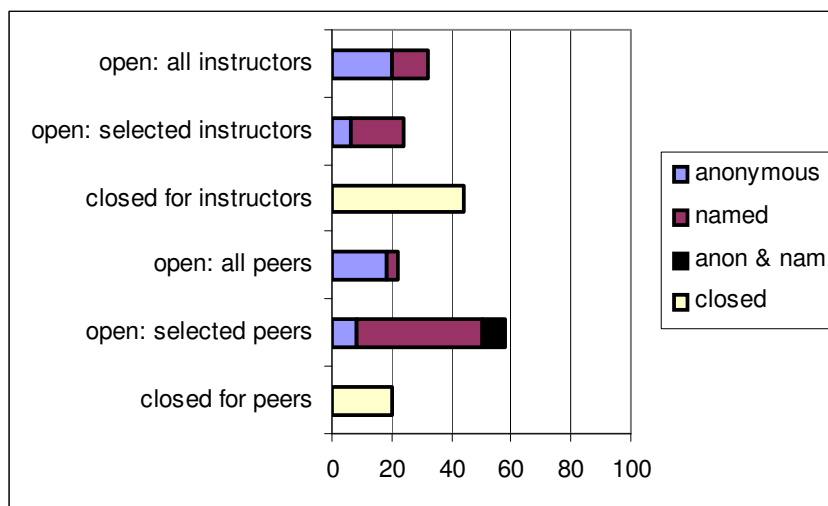
Figures 5a, 5b and 5c give the details of the percentage of students who chose to open their learner model to others in named and anonymous form.



**Figure 5a.** Opening the learner model to others: to whom and how amongst a small group (12: logs)



**Figure 5b.** Opening the learner model to others: to whom and how amongst a medium-sized group (26: logs)



**Figure 5c.** Opening the learner model to others: to whom and how amongst a large group (50: logs)

As also seen in Figure 4, Figure 5a shows that in the small group of 12 MSc students, only 1 chose *not* to open their learner model to instructors, and 1 chose *not* to open their model to peers. These were different students in each case. Most opened their learner model to all peers and instructors; half anonymously and half named in both cases. Where students opened their learner model to selected peers and instructors, the tendency was towards opening a named model.

The learner model opening patterns in the medium-sized group of 26 3<sup>rd</sup> year students are given in Figure 5b. A little under one half of the students kept their learner model hidden from the instructors; and half opened their learner model to all instructors, most of whom doing so anonymously. 1 student opened their model to selected instructors, with their name available. A higher proportion (54%) opened their model to all peers than to selected peers (19%); most opening it anonymously when opening to all peers, and all opening to at least some of their selected peers with their name (with one also opening to some additional peers anonymously). Thus 73% of students released their learner model either to all or selected peers, in some form.

Figure 5c shows that in the group of 50 MSc students, a similar proportion of students kept their learner model hidden from instructors as in the group of 26. However, a much lower

percentage (32%) opened their model to all instructors (but similarly to the larger group, most doing so anonymously); and around one quarter opened their learner model to selected instructors only - mostly with their name attached. A smaller percentage (20%) than in the medium-sized group withheld their learner model from their peers. In contrast, a much larger proportion opened their model to selected peers (mostly named). Those who opened their learner model to all peers mostly did so anonymously. 80% of students opened their learner model to at least some other students, in some form.

As illustrated in Tables 1a, 1b and 1c, the logs show no clear pattern of similarity or difference between opening the learner model to instructors and peers in named or anonymous form. The greatest tendency in the small and large groups (Tables 1a and 1c), though still not a majority, were those who opened their learner model to both their instructors and peers in named form. In the medium-sized group (Table 1b), the largest minority tended towards opening the learner model anonymously to instructors and peers.

**Table 1a.** Opening the learner model to others:  
similarities and differences in opening to instructors and peers amongst a small group (12: logs)

<i>Open to</i>	<i>peer named</i>	<i>peer anonymous</i>	<i>peer n &amp; anon</i>	<i>peer closed</i>
<i>instructor named</i>	4	2		
<i>instructor anonymous</i>	2	2		1
<i>instructor n &amp; anon</i>				
<i>instructor closed</i>		1		

**Table 1b.** Opening the learner model to others:  
similarities and differences in opening to instructors and peers amongst a medium-sized group (26: logs)

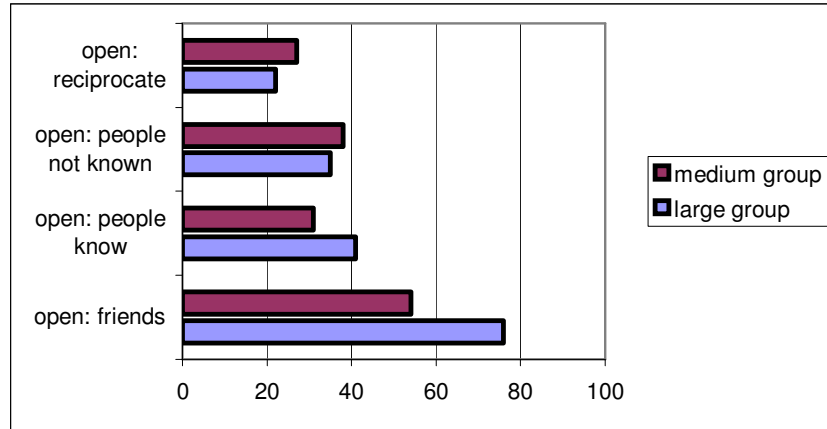
<i>Open to</i>	<i>peer named</i>	<i>peer anonymous</i>	<i>peer n &amp; anon</i>	<i>peer closed</i>
<i>instructor named</i>	3			1
<i>instructor anonymous</i>		9		1
<i>instructor n &amp; anon</i>				
<i>instructor closed</i>	4	2	1	5

**Table 1c.** Opening the learner model to others:  
similarities and differences in opening to instructors and peers amongst a large group (50: logs)

<i>Open to</i>	<i>peer named</i>	<i>peer anonymous</i>	<i>peer n &amp; anon</i>	<i>peer closed</i>
<i>instructor named</i>	11	2	1	1
<i>instructor anonymous</i>	4	7	1	1
<i>instructor n &amp; anon</i>				
<i>instructor closed</i>	8	4	2	8

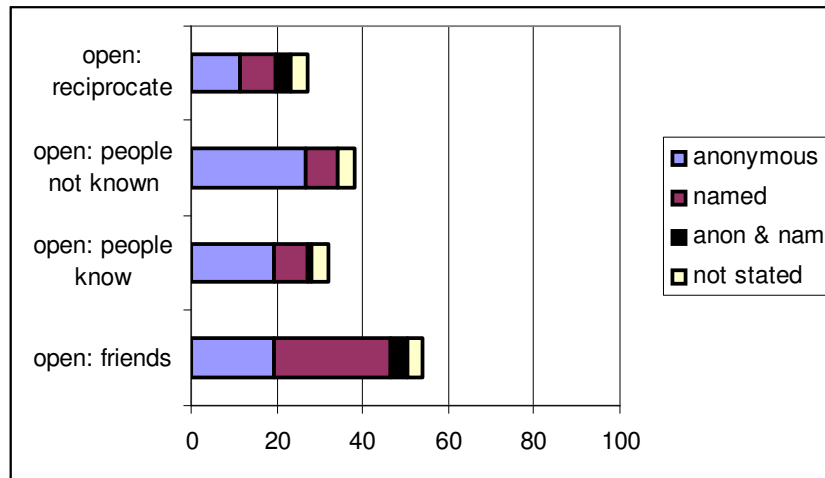
However, there were also learners who would open anonymously to both instructors and peers in the small and large groups, and named to instructors and peers in the medium-sized group. In the small and large groups there were also students who opened their model anonymously to one group and named to the other. In the large group, those who did not open their learner model to their peers usually did not open it to their instructors. This was true in 8 of the 10 cases of keeping the learner model closed to peers. However, the reverse was not the case - 8 people kept their learner model hidden from both peers and instructors in the large group, while 14 kept it hidden from instructors only; and 5 kept their learner model hidden from both peers and instructors in the medium-sized group, while 7 kept it closed to instructors only, and 2 to peers only. The small group of 12 was different as most people opened their learner model to others, with only 1 person keeping their learner model hidden from instructors, and 1 from peers - these being different students in each case.

In the small group of 12, students knew each other quite well and, as described above, opened their learner model to most others. According to the questionnaire answers from the 26 (of 26) and 46 (of 50) respondents from the medium-sized group and large group respectively, the comparison of percentages in Figure 6 shows that learners tended to open their learner model most often to their friends (54% in the medium-sized group and 76% in the large group), with lower levels of accessibility for those they knew less well.

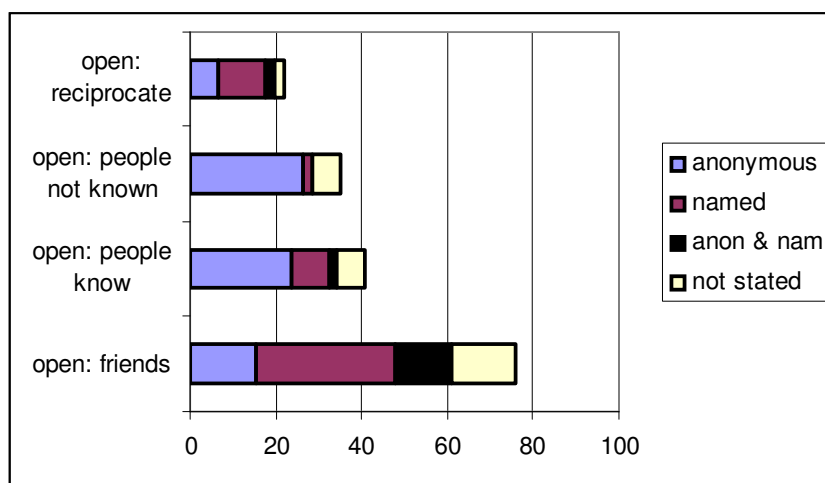


**Figure 6.** Opening the learner model to peers in a medium-sized group (26: 26 questionnaires) and a large group (50: 46 questionnaires)

Figures 7a and 7b provide the breakdown of whether learner models were opened named or anonymously to friends, those known less well, those not known (or known only slightly), or in reciprocation (i.e. where a model is opened in response to a model received from someone else, where it would not otherwise have been released to that person), in the medium-sized and large groups.



**Figure 7a.** Opening the learner model to others: friends / known / not known in a medium-sized group (26: 26 questionnaires)



**Figure 7b.** Opening the learner model to others: friends / known / not known in a large group (50: 46 questionnaires)

The main difference between the medium-sized and large groups was that more students in the larger group were specifically opening their learner model to their friends (but with a tendency towards opening named models in both groups). Nevertheless, in each case 'opening to friends' formed the largest category. In the large group, opening the learner model in reciprocation (i.e. opening one's own model to someone because they had released theirs) had a greater proportion of students doing so with their identifying details available. In both groups, learner models opened to people known less well, or not at all, were most often released anonymously.

The questionnaire administered to the medium and large groups asked students how useful it was to view their own and other people's learner models. Table 2 shows the comparison of students finding each type of model helpful, with most in each group finding their own and the group models useful, and some finding the individual peer models useful.

**Table 2.** Utility of viewing own and peer models in a medium-sized group (26: 26 questionnaires) and a large group (50: 46 questionnaires)

<i>Useful</i>	<i>own</i>	<i>peer named</i>	<i>peer anonymous</i>	<i>group</i>
<i>medium</i>	20 (77%)	10 (39%)	8 (31%)	16 (62%)
<i>large</i>	40 (87%)	22 (48%)	14 (30%)	36 (78%)

Most students in the medium-sized group, 20 of the 26, claimed that viewing their own learner model was useful for their learning. Of the remainder, 4 stated that they found at least one type of peer model useful. Thus only 2 of the 26 students did not find any aspect of UMPTEEN useful. Of the 26 students, 10 found it useful for their own learning, to view the named models of peers; and 8 found it useful to view anonymous peer models. 3 of these responses were from the same students – i.e. 3 students found both anonymous and named individual models helpful. 16 of the students found the breakdown from the group model helpful. 11 of these found at least one of the methods of viewing individual peer models, useful, with 5 finding only the group model to be helpful. There were 4 cases where students found at least one form of individual peer model to be helpful, but did not find the group model useful.

40 of the 46 students in the large group found viewing their own learner model to be useful for their learning. Of the remaining 6, all but 1 stated that they found at least one type of peer model to be helpful. Thus only 1 of the 46 students did not find UMPTEEN useful at all. 22 of the 46 students found it helpful to view the named models of peers; 14 found it useful to view peer models anonymously. 9 of these students found both the anonymous and the named individual peer models useful. 36 of the students found the group model overview helpful. 22 of these 36 found at least one type of individual peer model to be useful; and 14 found only the group model useful. 6

students found at least one type of individual peer model useful, but did not find the group model to be helpful.

Tables 3a and 3b provide data on opening the learner model by the strongest and weakest students in the medium-sized and large groups (the small group is too small for this type of analysis to be useful). Strong students are here defined as those in the upper quartile of their group as measured by their learner model; weak students are defined as those in the lower quartile. The numbers in brackets refer to the number of users opening their model to all peers or instructors, rather than selecting individuals. The main (unbracketed) figure includes both types of opening. In the large group there were 11 individuals who were considered to have attempted too few questions across topics to judge their overall ability. They have therefore been omitted from the calculation of upper and lower quartiles. 39 individuals qualified for the analysis.

**Table 3a.** Opening the learner model to others: strong and weak models in a medium-sized group (26: logs)

Key: strong - upper quartile; weak - lower quartile;  
(number in brackets) - opened the learner model to all instructors/peers

<i>Open- ing</i>	<i>instr: named</i>	<i>instr: anon</i>	<i>instr: n &amp; anon</i>	<i>instr: closed</i>	<i>peers: named</i>	<i>peers: anon</i>	<i>peers: n &amp; anon</i>	<i>peers: closed</i>
<i>strong</i>	0	5 (5)	1	1	0	4 (4)	1	2
<i>weak</i>	1	2 (2)	0	4	1	4 (4)	0	2

**Table 3b.** Opening the learner model to others: strong and weak models in a large group (50: 39 logs)

Key: strong - upper quartile; weak - lower quartile;  
(number in brackets) - opened the learner model to all instructors/peers

<i>Open- ing</i>	<i>instr: named</i>	<i>instr: anon</i>	<i>instr: n &amp; anon</i>	<i>instr: closed</i>	<i>peers: named</i>	<i>peers: anon</i>	<i>peers: n &amp; anon</i>	<i>peers: closed</i>
<i>strong</i>	1 (1)	5 (4)	0	3	2 (2)	5 (1)	1	1
<i>weak</i>	2 (1)	3 (1)	0	4	2 (1)	5 (1)	1	1

The numbers here are relatively small: 7 strong and 7 weak students from the medium-sized group; and 9 strong and 9 weak from the large group. We therefore do not wish to seek patterns in the data. Nevertheless, it is interesting to note that there were no clear differences between the stronger and weaker students in their preferences for opening their learner model to others.

Tables 4a and 4b show responses to the questionnaire items asking whether students preferred to view specifically, the (named) learner models of people they thought were stronger, weaker or at about the same level of knowledge in the subject; and whether they opened their own model to people they thought were stronger, weaker or similar.

**Table 4a.** Viewing peer models and opening the learner model to peers in a medium-sized group: ability (26: 26 questionnaires)

<i>Peers</i>	<i>stronger</i>	<i>similar</i>	<i>weaker</i>	<i>irrelevant</i>
<i>open</i>	6	8	4	16
<i>view</i>	12	9	4	10

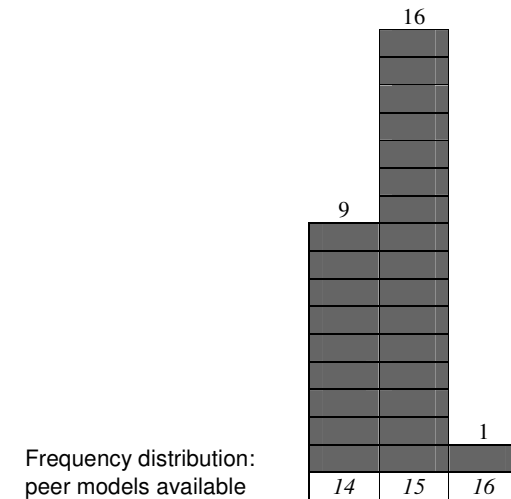
**Table 4b.** Viewing peer models and opening the learner model to peers in a large group: ability (50: 46 questionnaires)

<i>Peers</i>	<i>stronger</i>	<i>similar</i>	<i>weaker</i>	<i>irrelevant</i>
<i>open</i>	11	15	8	29
<i>view</i>	30	24	8	12

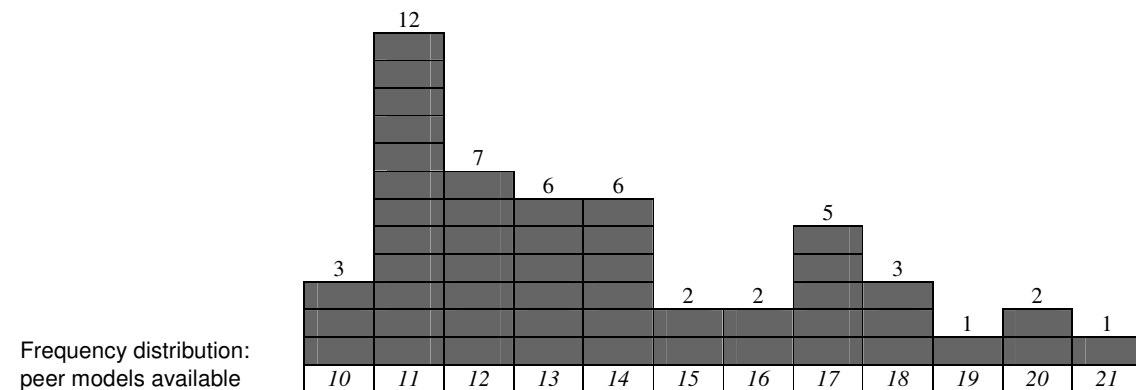
Table 4a shows that in the medium-sized group, students were most interested in viewing the learner models of those they thought were at a similar or higher level than themselves. In general (though not exclusively), they were less interested in the models of those they thought were weaker. 10 (38%) of the students did not find the level of knowledge of others to be an important factor when choosing which of the learner models to view. The ability of others was not relevant to most students when considering who to open their learner model to, with 16 (62%) *not* selecting people specifically with knowledge or beliefs about their level in mind.

In the large group, as shown in Table 4b, the trends were similar (but stronger). Most students were interested in viewing the learner models of those at a similar level, or a higher level than themselves. Similarly, they were generally less interested in the models of those they considered weaker. 12 (26%) of the students did not consider the knowledge level of peers to be important when selecting learner models for viewing. The knowledge level of peers was not considered important by most students when choosing who they wished to open their learner model to. 29 (63%) were *not* selecting people according to their own beliefs about those peers' ability.

Students in the small group had nearly all learner models available to them, as 10 of the 12 students opened their model to all peers. Figures 8a and 8b show the frequency distribution of peer models available to students in the medium-sized and large groups.



**Figure 8a.** Frequency distribution of peer models available to individual students in a medium-sized group (26: logs)



**Figure 8b.** Frequency distribution of peer models available to individual students in a large group (50: logs)

Because 14 students in the medium-sized group (Figure 8a) opened their learner model to all their peers (11 anonymously and 3 named), all students had at least 14 models available (potentially this could have been 13 if a student was amongst those who opened their own model to

all). The range was very narrow: 14-16, meaning that all students had access to 54-62% of the models in the system. In the large group (Figure 8b), 10 students opened their learner models to all peers (8 anonymously and 2 named), and all users had at least 10 individual peer models available to them. The range was 10-21, with a positively skewed distribution: median 13 (26% of the models in the system); mode 11 (22% of the models). Only 3 people had no additional individual models available to view, apart from those that were opened to all peers (thus having access to 20% of the models). The 3 students with 20 (40%) and 21 (42%) models to view, opened their own models in named form, to 8, 9 and 11 people, thereby encouraging others to open to their models to them. The student with 19 (39%) models opened their model in named form to 3 others, and anonymously to 26 people.

In addition to the fixed-choice questionnaire responses in the medium-sized and large groups students were asked to expand on their answers in open-ended format. Their comments were revealing, providing information not available from the fixed-choice answers. Given the insights offered by these explanations, and the variety of points arising, we include a broad selection here. The examples reproduced below are representative illustrations of how students said that they used the UMPTEEN learner models, comprising approximately 20% of the relevant comments. As can be seen, most comments were positive (the bias towards positive comments in the examples reflects the bias of the data). The selected comments cover all issues arising. (Note that some students were not native English speakers - their language errors have been preserved in the excerpts.)

*Viewing one's own learner model: positive*

- UMPTEEN helped me to understand gaps in my knowledge and things I was unsure about. It also made me realise my strengths in the subject.
- It made me realise I had misconceptions in some areas I thought I knew well, this made me think again about what I know.
- The learner model showed a direct picture of my C ability, this is really helpful. I can arrange my future study in C programming.
- The list of my understanding for each topic of C programming helps me to remind my weaknesses and strengths next day.
- I opened the learner model straight away because I was interested to see how I'd done in the questions... When you normally begin to learn about a subject you don't really know how much of the content you understand. I like to know how I'm doing in my work (what level I'm at)... For me being able to view the OLM is a confidence booster.
- During the first time I used it, I asked for retest of the concept of array size and index three times, but there was no change about the representation, then I concluded it was true that I knew a little knowledge about this concept.
- Accessing the learner model provided me the chance to self assess my progress by constantly referring to it. It also clarified the areas that I'm strongest at in C programming, and pointed out my weaknesses, which could be considered as a recommendation of what should be studied further. I realized I had performed better than I expected in some areas. More than that, it clarified misconceptions. Now - according to my learner model - I have a fair and better understanding of the fundamental concepts.
- I felt that the most useful thing was the way that it identified misconceptions that I had about the topics, as it gives you something specific to look into further, and can in effect significantly improve your understanding in that area.
- Comparing my level of knowledge with that of the domain, which was quite low at the beginning, created a motivating factor for me to improve my knowledge and my level of skill in each concept so that I can reach a reasonable level which I believe I was able to achieve, and that made me grow in confidence as I saw the progress that I've made.
- Helped me to set goals i.e. gain more stars in all areas.

*Viewing one's own learner model: negative*

- After viewing my open learner model, I know I have weak knowledge in array size and index, so I think viewing my learner model is useful, but not so strongly, because when I choose which parts to

be tested, I refuse to choose two parts, only chose the other parts I thought I am good at, aim to get reasonable mark. So I can not know my learning progress on a whole clearly.

- UMPTEEN was good, but it didn't show the answers that we got wrong.
- It doesn't give me some advice about my learning.

*Viewing peer models (individual and group): positive*

- I did not understand how learner model of others could help my learning at the start, however, I have found learner model of others useful to recognise my strengths and weaknesses.
- I feel as a person that I'm quite competitive. So the opportunity to see how my peers had fared with the same test was something I really wanted to do. It was interesting to compare my worst subject areas with other people's to see if they had struggled with that area. My first feeling was not to try and get the highest mark but to get above average (this is the first figure that really meant anything to me), these figures helped to provide goals.
- Viewing the learner model of my peers enabled me to compare my progress. My aim after the comparison was to improve myself, and to be up there with my colleagues, and the open learner model provided an interesting and motivating environment to achieve that.
- Comparison can tell in which level you are. If you know just your score, you can not know whether that is good or not. In short, you need comparative assessments to know in which level you are.
- Comparing with others can let us know which level we are in. Is my performance much better than I supposed, or although I did well, I just reached the average level?
- Allowing me to view other people's [models] made me aware that I was at a similar level to them, as I thought they knew more.
- If my knowledge is under the average level of my class, I will get a lot of pressures, then, I will study harder and practice more than before. This is good for my learning.
- Viewing other peers' learner model is really an intriguing thing, and I am sure it will be a help. It helps me to know, am I a good student or a poor student in this group... In my opinion, which level I belong to is more important than the mark.
- Viewing the group model let me know not only one out of three students have problems on concept of array size and index, it let me to realize that I am performing better than I thought, low mark on this concept is not all my fault, it is actually quite difficult for students, what I need to do is do not lose my courage and confidence, study hard.
- It was a confidence boost to see your own scores compared to others. Even if you didn't do well there were many people doing the same and this was encouraging.
- Compared with the group, I had a good understanding on array size and index. Of course it gave me much confidence. Although I had only fair knowledge in the concept pointers and addresses, a lot of students had the same problem as well, probably we should ask for help from our instructor. And I realised that I ought to get better in the concept do-while loop and while loop, I have to improve it by myself.
- Only from one's own learner model, it is hard to get a comprehensive view of the difficulty level of the domain. But with the learner models of others, one can compare his own learner model with others to get some idea about the difficulty level... When I find I fall behind, I will make more effort to come up with others. When I go ahead, it will give me confidence to encourage me to make further progress... Viewing learner models of others can let me know who is better than me, and if I have some problems that I can't solve, I could look for their advice to help me out.
- By viewing the learner models of others, I can know my level in my class or in my group. When I encounter puzzles, I can choose whom to communicate with.
- Although I registered my own results as anonymous it did enable me to see how my colleagues were achieving and helped me identify people to ask for help on specific areas.
- When I click on the person's name xxx, I find he has similar knowledge in the concepts of pointers and addresses. Then we can help each to discuss this concept, which improve both of our knowledge. And when I open the person named yyy, he has better knowledge than me in the concept of bitwise and logical operators. I can learn more from him. ... When someone knows my strong parts, they can get some help from me.
- Viewing their learner models with details let me know who has the same misconception as me and who is better. I consulted them and discussed together. For example, xxx has more experience in array size and index and he told me some details in array concept and boundary situation, which is my misconception. After that, we answered questions again and each of us felt this intercommunication was more effective than usual.

*Viewing peer models (individual and group): negative*

- Looking at average [group] student model insisted me to stop looking for more knowledge since, being above the average give me a satisfaction feeling.
- In the situation that the most students are better than me in their learner model, I think viewing others' models will not help me a lot because this may do harm to my self-confidence and lead me to give up the learning if there is a big gap between others and me.
- The option to use others' models did not help very much as I did not know who those models related to. I can however see how this would work in a situation where users know about their peers' topic understanding. This would only work if they shared their user names as well.

*Opening the model to peers: positive*

- The peers who open their models with personal details to me are my close friends. They prefer to trust their friends. There is one student to whom I am not familiar, she showed me hers. In my thought, she trusts me, so I opened mine to her.
- I opened it to my friends because we can know us well and then we can help each other, which is good for improving our studies. I opened my model with personal details to xxx just because that he opened it to me for civility although I didn't plan to do that before.
- I believe it is polite to offer something when you want to get something from the others, so aim to compare my model with peers, I open my model first. But I choose to open it anonymously to those persons who I am not familiar with. We just need to compare with the other peers, do not need to know their name.
- I get information from others' learner model, so I think it's my responsibility to open my learner model to others. That's fair.
- If I open my learner model to my peers, they are more likely to let me view their models as well. Collaboration is important.
- It creates atmosphere of positive competition.
- Some students show their details to each other, as by doing that, a small group is formed, so that those who have same level of knowledge could compete with each other and help improve their knowledge. Several students doing this are top students who have excellent records, and don't need to hide their learner models.
- As I didn't get a good mark in the test, I opened my learner model to all the peers anonymously. Lots of my classmates did better than me. Definitely this will be a spur to encourage me to review C programming immediately. Maybe this will make someone who did as bad as me feel better. At least, he or she was accompanied.
- I asked for some people to whom I showed my model to open their models because I could compare against theirs. In addition there were some people asked me to open my model to them and they opened theirs to me at the same time.
- I decided to open my learner model to other peers but anonymously. Allowing students to compare themselves to other students can provide encouragement and motivation. The reason for making my learner model anonymous is the same reason why people like to get their results without other people knowing. If you have done poorly then you don't really want people to know that fact. In contrast if you obtain 100% then I wouldn't want people to know because you would have a stigma attached to your character.
- I opened my learner model to other students because I think maybe it is helpful to others. But I do not want others to know how is my performance. If I do well, it will result in a bad effect because some students would think those actions indicate that I am showing off to them. That is factor about culture. So I selected the way is anonymously.
- I think it's better to discuss with a classmate than the instructor because I and my classmates are of the same level. When it comes to the instructor, question and answer will be instead of discussion.

*Opening the model to peers: negative*

- Whatever I did well or badly, it's just my business. And I do think there's no need to let others know, especially someone I don't know very well.

- As I was not totally sure on certain topics I was reluctant to identify myself when I opened my model. I am aware this is a problem as peer models are recognised as a valuable learning aid, I personally just felt a little uncomfortable with publishing my results.
- I think my mark is not quite good. When somebody else sees my mark, they may laugh at me.
- My learner model was not good. Therefore I did not open it. I thought I would feel a shame if I opened it. After all, I do not have concrete reason to be kind enough to do it, so I did not.
- I didn't want the others to know my personal achievement, because the result was poor. So I didn't open my learner model to my friends, not even anonymously.

*Opening the model to instructors: positive*

- I think if everyone opens his or her model, the instructors can get more accurate feedbacks, which can help tutors to better understand their students and adapt their ways.
- If the instructor just know my learner model without my name, it will only help the instructor to have a general view of all the students' learning process, thus they can't give me the individualized tutoring. If the instructors know more about my learning process, they will give me more correct guidance. So why not let them know the details?
- Instructors can know their students well in order to give them individual suggestions and study plans. What is more, instructors can explain their problems in coming lectures.
- The reason I anonymously opened my learner model is to ensure that the instructors and peers get the objective information of their students or peers. It is the content of the learner model rather than the names of students that really matters.

*Opening the model to instructors: negative*

- I didn't want to open my learner model to all the instructors because my performance in the test is not good enough, even shameful. Plus the learner model has told me about which concept I am not good at and in which concept I should put my shoulder to the wheel.

### **3.3 Discussion**

UMPTTEEN was designed for use by a range of students - those who like to work individually, who may or may not wish to compare their learner model with models of peers; those who enjoy collaborative learning who may use the peer models to seek learning partners, or as a starting point for understanding their respective knowledge in discussion; or competitive learners who strive to outperform others, who may check their progress against peers without necessarily interacting with those other students.

It is perhaps not surprising that amongst a small group of learners who know each other well, students would be more willing to open their learner model to their peers. As shown in Figure 4, 92% of learners in the small group opened their model to other students, with 83% opening it to all peers (Figure 5a). In the other groups, a high percentage of learners also chose to open their learner model to other students, with 73% (medium-sized group) and 80% (large group) choosing to do so. The patterns were different, however, with more opening their learner model to all peers in the medium-sized group - 54% (Figure 5b). In the large group, only 22% of students opened their learner model to all peers (Figure 5c). In each case, the majority of these opened their model anonymously, which differed from behaviour in the small group where half opened their model with their names, and half anonymously. It appears that, amongst larger groups (with 26 being sufficiently large), most students prefer to keep their identity hidden when opening their learner model to everyone. The numbers opening their learner model to selected peers only, varied in line with the proportion opening to all peers - i.e. in the small group only 1 learner (8%) chose specific peers to release their model to; in the medium-sized group 19%; and in the large group, 58%. Thus in the group with the lower proportion of students opening their learner model to all peers, more were opening to selected others. In all groups, most of those choosing specific peers were willing to attach their name to their learner model. The fact that in the largest group, fewer students were opening their learner models to all peers, may be a factor of group size - perhaps 26 students is still small enough for students to know each other sufficiently well to open their model to all, albeit

mainly anonymously. Further investigation into use of this approach in groups of different sizes may clarify this.

In the small group, the majority of learner models were available to all. Figures 8a and 8b show that the proportions are lower as the size of group increases, but there are still a reasonable number of individual peer models available for all: 54-62% in the medium-sized group (i.e. over half); and 20-42% in the large group. Given the comments in the questionnaire responses, this appears sufficient for students to find viewing the individual models of others to be helpful for their own learning.

In general fewer students tended to open their learner model to instructors in the two larger groups (Figure 4), with 54% doing so in the medium-sized group, and 56% in the large group, compared to 92% in the small group. This may be a result of the small group being volunteers, while the other two groups used UMPTEEN during scheduled lab sessions. Nevertheless, the fact that in these two groups a little over half the students were opening their learner model to their instructors, suggests that this is considered a useful feature by sufficient numbers of students to continue this facility. Maintaining this level of interest by students will likely depend on the use that instructors make of the models of their students, in practice.

Some students in the small and large groups opened their learner model to instructors with their name, while others did so anonymously. While this was also true in the medium-sized group, the majority of those opening their learner model to instructors did so anonymously. It is not obvious why this is the case - it may simply be that people who opened to peers anonymously, may be more likely to open to instructors in the same way; or that students were seeing a higher proportion of anonymous peer models, and so assumed others might be more likely to open their learner model to instructors anonymously, and therefore did the same themselves. An interesting scenario might be that usage in courses may depend as much on choices made by those registering for the system first, as on individual preferences - i.e. if the first students open to peers anonymously, this may affect others' behaviour when opening their learner model to peers, and perhaps also to instructors. This issue deserves further attention.

According to Tables 1a and 1c, relating to the small and large groups, it appears difficult to predict whether an individual will want to open their learner model to peers and instructors in the same format (i.e. named or anonymously). There was a clearer trend for opening the model in the same format in the medium-sized group, but it is difficult to draw any conclusion from this given the different behaviour in the other two groups. It is also difficult to predict whether students will want to open their learner model to both groups - though those keeping their learner model hidden from peers tended to also withhold it from instructors in the medium-sized and large groups. However, the reverse is not true - students withholding their model from instructors did not necessarily keep it hidden from peers. As discussed above, most students in the small group tended to open their learner model to instructors - possibly an effect of these students having volunteered to participate. Given the differing choices by individuals for how and to whom to open their learner model, we would suggest supporting all possibilities, in any combination.

Students in the two larger groups were able to make choices about which type of students to open their learner model to, that were not available to the students in the small group who knew each other better. As shown in Figure 6, more chose to open their learner model to their friends, but with some also opening it to others. Some were also willing to open their learner model in reciprocation - i.e. to those who opened to them. Some friends received named models, while some received anonymous models from their friends. For people known less well, perhaps unsurprisingly, the proportion of named models was smaller. For those opening in reciprocation, the proportion of anonymous versus named models was more similar to models opened to friends. Thus there seems to be a difference in students' perceptions of those who opened their learner model to them, from those who did not (at least, in named form, where students could be identified).

Given that sufficient students seem willing to open their learner models to others to make the UMPTEEN approach potentially useful, the key question is whether students find it helpful to view the learner models of their peers and, furthermore, since those opening their learner model most widely in larger groups tended to do so anonymously, whether students find unnamed models to be helpful. While Table 2 shows that most users found their own and the group models useful,

there were 58% and 59% for the medium and large groups respectively, finding at least one form of individual peer model useful. While more users found named models useful, over half of those interested in individual peer models found anonymous models helpful. This is sufficient to maintain the option for anonymous individual peer models in UMPTEEN, for those who find them a useful reference. It also permits those users who are reticent about releasing a named model, an option to release it unnamed, allowing more models to be available to users.

It is interesting to look at the behaviour of learners of different ability levels, as indicated by their learner models. As shown in Tables 3a and 3b, the upper and lower quartiles were investigated in the two larger groups (with 11 of the larger group being barred from the analysis due to their more limited coverage of topics in the multiple-choice questions, making it difficult to judge their overall competence). Given the small numbers involved (7 in each quartile in the medium-sized group and 9 in the large group), we do not wish to identify particular patterns with a view to making predictions about user preferences according to ability, but rather, simply to observe whether there could be trends to investigate further. From the numbers involved, there were no obvious patterns, suggesting tentatively that a learner's ability is not a key factor in general, in the decision to open the learner model to peers. In the medium-sized group, more of the weak students kept their learner model closed to instructors, but there was little difference in the large group.

In choosing whether to open the learner model to those they consider stronger, weaker or of a similar level of ability, Tables 4a and 4b show that in relation to opening their model, a majority consider this irrelevant. Of those who opened their model with an awareness of their judgements of the competence of others, in both groups more were targeting those at a similar, and to a lesser extent, higher level of ability. When viewing the models of others, in general students in both groups were more interested in viewing the models of those at a similar, or in particular, higher level than themselves. Nevertheless, the qualitative comments from students show that some find it a strong confidence booster to see the learner models of weak students if they believe their own knowledge to be low, so we would not wish to deter weaker students from opening their models if they are happy to do so.

The qualitative comments are able to show in a much greater level of detail, how students really perceived the UMPTEEN approach. There were both positive and negative comments for all aspects of UMPTEEN, though the positive comments far outweighed the negative ones. For example, for viewing one's own model students found it helpful to see both where their knowledge was good, and where there were problems - including misconceptions. Many appeared to find it a useful tool to aid self-assessment for formative purposes, and mentioned benefits related to motivation, goal-setting, and the learner model as a reminder of one's knowledge on a subsequent login. Nevertheless, 1 student found that they avoided topics in which they considered themselves to have problems, in order to avoid negative data in their learner model. However, this was the only case from the 72 questionnaires from the two larger groups. A few students felt that they would have preferred UMPTEEN to identify specific questions that they had answered incorrectly, and provide further guidance. As UMPTEEN was being evaluated in isolation from other feedback specifically to assess its potential alone, with a view to possible later integration into a larger system or with support from postgraduate teaching assistants, this minority of comments need not concern us too much. There were more students finding the approach generally helpful, than finding it lacking.

When it came to viewing peer models, there were a range of reasons for doing so. Some students found it useful to be able to compare their knowledge against that of other students rather than against the expert knowledge, to better gauge their relative progress - i.e. a weak model does not necessarily mean that someone is doing particularly badly if other learners are also having problems in the same area. Confidence was often mentioned in relation to this, and some found it motivating to realise that they were perhaps not as far behind as they had thought. Some were using the models of others competitively, to try to outperform them, while others were more interested in collaboration and the possibility of finding suitable learning partners. However, a minority found viewing peer models to be a negative experience - in one case confirming good knowledge and so leading the student to discontinue their learning, but in a few cases damaging self-confidence. There is an important question of whether we should withhold peer models in order to protect a

small minority for whom this is demotivating, or whether we should encourage the sharing of learner models in order to support the higher number who find them useful - including those with relatively low levels of knowledge compared to others. Of course, learners do not have to view peer models, but it may be difficult to stop oneself from accessing them if they are available. We do not have an answer to this question, but suggest it should be considered further, in relation to contextual issues relevant to the system users (e.g. learner age, type and level of course, expected learning outcomes, cultural issues related to learning, etc.).

Students opened their learner model to their peers for a variety of reasons - some citing 'politeness' or 'fairness' in relation to those who had opened their model to them; some stating that they wished to make those who had done badly feel better, i.e. to realise that they were not the only ones with problems; some wanting to encourage collaboration; and some to encourage competition. An interesting viewpoint emerged from some of the stronger students, who stated that they preferred to open their learner model anonymously in order not to be thought of as 'showing off' their superior knowledge. This is interesting given that other students were keen on seeking learning partners, and perhaps for those individuals, knowing the identity of someone who has good knowledge might have enabled them to seek help. Perhaps a facility where students could sign up to receive assistance on specific topics, would be used by some of those who could offer help, and so avoid the need for such students who were reluctant to reveal their identity, to do so. (For example, the I-Help one-to-one help system (Bull et al., 2003; Vassileva et al., 2003) allows participants to remain anonymous if they wish.) In contrast, a few students felt that their own knowledge should be of no concern to others. Some of the weaker students were more reluctant to open their models, but as we have seen, there were sufficient weaker students opening their models that this appears not to be a problem - i.e. students are not getting an unbalanced view of their group's knowledge. (Indeed, even if this were an issue in a specific group, the existence of the group model should alleviate this.)

Students tended to think it would be useful for instructors to gauge the problems of the group, in order to adapt their teaching; or for them to know the problems of an individual in order to help that person specifically. This would be practical in a lab session, for example, where postgraduate teaching assistants could examine the knowledge of an individual before giving them help. Alternatively, postgraduates could be assigned to monitor learner models remotely, offering assistance as individual problems arise, passing on information more generally to the course instructor to deal with in lectures, or for treatment in tutorials. One student was reluctant to open a weak model to instructors precisely because it was weak, but further explained that this was not necessary because they had been able to identify for themselves, where their problems lie, and so could look into strengthening their knowledge in those areas themselves.

The results discussed above apply to experienced students (3<sup>rd</sup> year and MSc) in an experimental setting. It has been shown that, in principle, sufficient students are willing to open their learner model to others and sufficient students find this a useful approach, to justify further investigation into the use of UMPTEEN alongside lecture courses throughout a term. This was an important first step before deploying UMPTEEN in real courses. We do not wish to recommend a specific method of releasing learner models in terms of all or selected individuals, named or anonymous models, given that learners have different preferences. Usage suggests that providing a choice of how and to whom to open the learner model, is important, and we would therefore recommend supporting all approaches where appropriate to the context. Current work is investigating the UMPTEEN approach in a range of course types at different levels in the Electronic, Electrical and Computer Engineering department at the University of Birmingham. These results will enable us to identify the utility and uptake of the approach in practice, and over time. It will also allow comparison of individual students' use of UMPTEEN in different courses. Future work will include investigation of the use of more complex open learner models that can be released to others, and instructors' use of the learner models of their students.

#### **4. SUMMARY**

This paper has described UMPTEEN and presented the results of the first investigation of student attitudes towards learner models that can be opened to instructors and peers, in an experimental setting. Some students chose to keep their models hidden from instructors and/or peers, while others chose to open their models to some or all others, named or anonymously. There was no single dominant way of using the learner models of others, suggesting that a range of possibilities should be offered. Sufficient numbers of learners in groups of different sizes were willing to open their learner models to their peers, in order for the approach to be considered useful for those who found peer models helpful. This is a key finding as, although the results reported here are from lab studies, the crucial question of whether students are willing to allow others access to information about their understanding has been addressed. Of course, we do not yet know what will happen in an authentic learning context, but we are now at the stage where we can recommend deployment of the approach in real courses. Such deployment had now commenced in university courses at different levels.

## REFERENCES

- Brusilovsky, P., Sosnovsky, S. & Scherbinina, O. (2004). QuizGuide: Increasing the Educational Value of Individualized Self-Assessment Quizzes with Adaptive Navigation Support, in J. Nall & R. Robson (eds), *Proceedings of World Conference on E-Learning*, Association for the Advancement of Computing in Education, 1806-1813.
- Bull, S., Brna, P. & Pain, H. (1995). Extending the Scope of the Student Model, *User Modeling and User-Adapted Interaction* 5, 45-65.
- Bull, S. & Broady, E. (1997). Spontaneous Peer Tutoring from Sharing Student Models, in B. du Boulay & R. Mizoguchi (eds), *Artificial Intelligence in Education*, IOS Press, Amsterdam.
- Bull, S., Greer, J. & McCalla, G. (2003). The Caring Personal Agent, *International Journal of Artificial Intelligence in Education* 13(1), 21-34.
- Bull, S. & McEvoy, A. (2003). An Intelligent Learning Environment with an Open Learner Model for the Desktop PC and Pocket PC, in U. Hoppe, F. Verdejo & J. Kay (eds), *Artificial Intelligence in Education*, IOS Press, Amsterdam, 389-391.
- Bull, S. & Nghiem, T. (2002). Helping Learners to Understand Themselves with a Learner Model Open to Students, Peers and Instructors, *Proceedings of Workshop on Individual and Group Modelling Methods that Help Learners Understand Themselves*, International Conference on Intelligent Tutoring Systems 2002, 5-13.
- Bull, S. & Pain, H. (1995). 'Did I say what I think I said, and do you agree with me?': Inspecting and Questioning the Student Model, *Proceedings of World Conference on Artificial Intelligence in Education*, AACE, Charlottesville, VA, 1995, 501-508.
- Bull, S., Quigley, S. & Mabbott, A. (2006). Computer-Based Formative Assessment to Promote Reflection and Learner Autonomy, *Engineering Education* 1(1), 8-18.
- Corbett, A.T. & Bhatnagar, A. (1997). Student Modeling in the ACT Programming Tutor: Adjusting a Procedural Learning Model with Declarative Knowledge, *User Modeling: Proceedings of 6th International Conference*, Springer Wien New York, 243-254.
- Dimitrova, V. (2003). StyLE-OLM: Interactive Open Learner Modelling, *International Journal of Artificial Intelligence in Education* 13(1), 35-78.
- Grigoriadou, M., Papanikolaou, K., Kornilakis, H. & Magoulas, G. (2001). INSPIRE: An Intelligent System for Personalized Instruction in a Remote Environment, in P. De Bra, P. Brusilovsky & A. Kobsa (eds), *Pre-Workshop Proceedings: Third Workshop on Adaptive Hypertext and Hypermedia*, User Modeling 2001, 31-40.
- Kay, J. (1997). Learner Know Thyself: Student Models to Give Learner Control and Responsibility, *Proceedings of International Conference on Computers in Education*, AACE, 17-24.
- Mabbott, A. & Bull, S. (2006). Student Preferences for Editing, Persuading and Negotiating the Open Learner Model, in M. Ikeda, K. Ashley & T-W. Chan (eds), *Intelligent Tutoring Systems: 8th International Conference*, Springer-Verlag, Berlin Heidelberg, 481-490.
- Mitrovic, A. & Martin, B. (2002). Evaluating the Effects of Open Student Models on Learning, *Adaptive Hypermedia and Adaptive Web-Based Systems, Proceedings of Second International Conference*, Springer-Verlag, Berlin Heidelberg, 296-305.
- Mühlenbrock, M., Tewissen, F. & Hoppe, H.U. (1998). A Framework System for Intelligent Support in Open Distributed Learning Environments, *International Journal of Artificial Intelligence in Education* 9(3-4), 256-274.

- Papanikolaou, K.A., Grigoriadou, M., Kornilakis, H. & Magoulas, G.D. (2003). Personalizing the Interaction in a Web-Based Educational Hypermedia System: The Case of INSPIRE, *User Modeling and User-Adapted Interaction* 13(3), 213-267.
- Rueda, U., Larrañaga, M., Ferrero, B., Arruarte, A. & Elorriaga, J.A. (2003). Study of Graphical Issues in a Tool for Dynamically Visualising Student Models, *Proceedings of Workshop on Learner Modelling for Reflection (Supplemental Proceedings volume 5)*, International Conference on Artificial Intelligence in Education 2003, 268-277.
- Vassileva J., McCalla G. & Greer J. (2003). Multi-Agent Multi-User Modeling in I-Help, *User Modeling and User-Adapted Interaction* 13(1), 179-210.
- Weber, G. & Brusilovsky, P. (2001). ELM-ART: An Adaptive Versatile System for Web-Based Instruction, *International Journal of Artificial Intelligence in Education* 12(4), 351-384.
- Zapata-Rivera, J-D. & Greer, J.E. (2004). Interacting with Inspectable Bayesian Student Models, *International Journal of Artificial Intelligence in Education* 14(2), 127-163.
- Zapata-Rivera, J-D., Underwood, J.S. & Bauer, M. (2005). Advanced Reporting Systems in Assessment Environments, *Proceedings of Workshop on Learner Modelling for Reflection*, International Conference on Artificial Intelligence in Education 2005, 23-31.