

# Computer support of effective peer assessment in an undergraduate programming class

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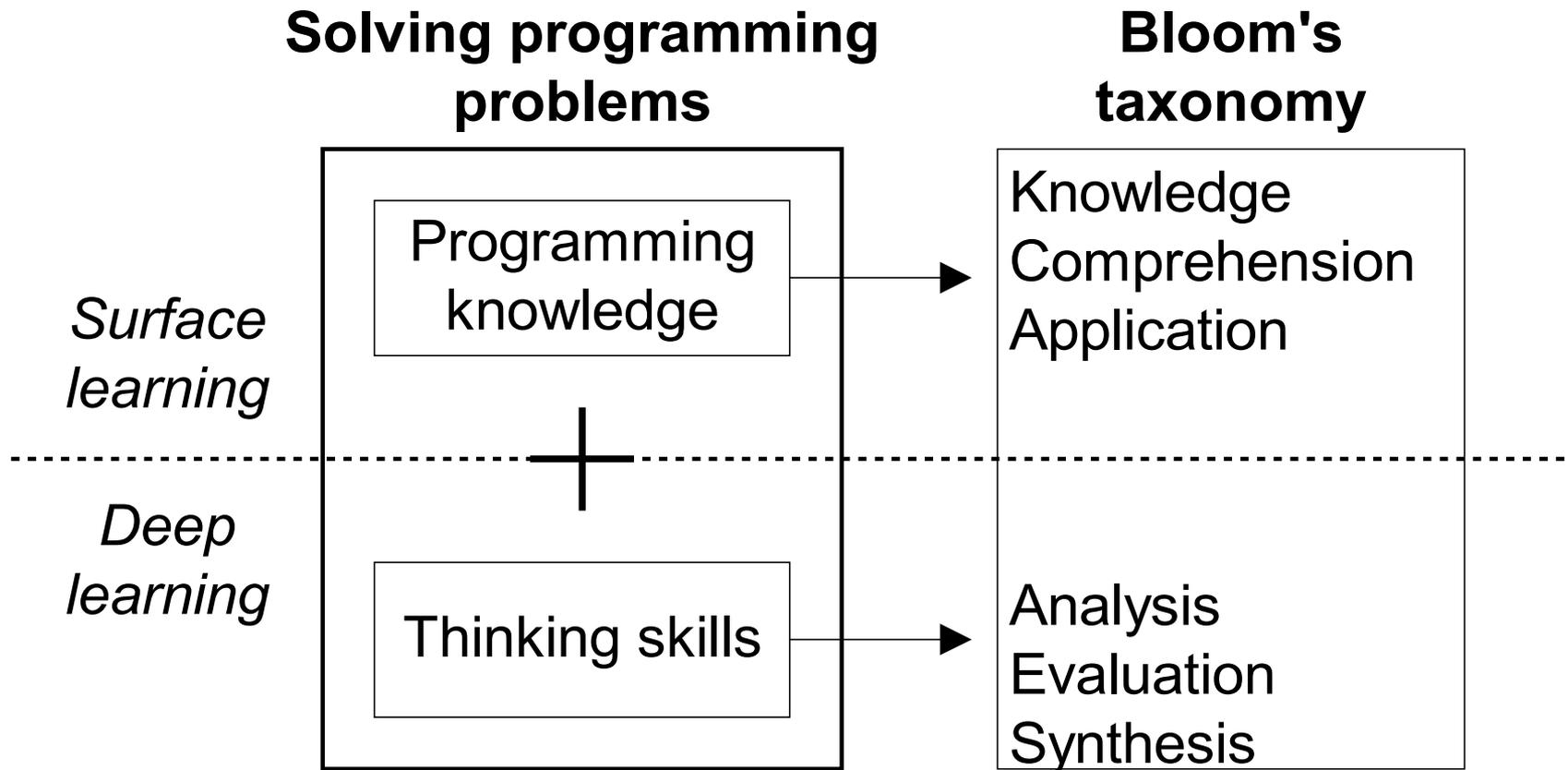
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# Bloom's Taxonomy & Learning Programming



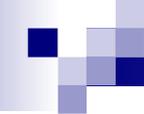
# Learning taxonomy in context of programming

Knowledge (remember)	The ability to remember programming syntax and structure.	<i>For example:</i> for/do/while repetition, if/else selection, case/switch multiple-selection, and the structure of each programming language.
Comprehension (understand)	The ability to grasp the meaning of the basic concepts of programming and to interpret a program.	<i>For example:</i> understand what the program does; understand different data types and conditional statement; understand the concepts of array, methods/functions, error handling techniques.
Application (apply)	The ability to write code fragments, solve programming problems by applying simple techniques, methods, and programming concepts.	<i>For example:</i> write a program to print out a thousand statements with the for/do/while repetition.
Analysis (analyse)	The ability to identify the parts of the program and analyse their relationship, compare programming utilities.	<i>For example:</i> identify the causes/faults of the program, identifying appropriate utilities.
Evaluation (evaluate)	The ability to judge the quality of a program, determine how well the program works (i.e. efficiency/stability/consistency).	<i>For example:</i> analyse the positive/negative features, judge which of two methods is the most effective solution.
Synthesis (create)	The ability to rewrite a program using creative thinking (other possible/different solutions) in order to improve it.	<i>For example:</i> rewrite a method to reduce redundancy of repeated code within the program in order to simplify the structure, which makes the whole program easier to follow and maintain.

# What is peer assessment?

Peer assessment is the process which involves students *making judgement* and *providing feedback* on other students' work.

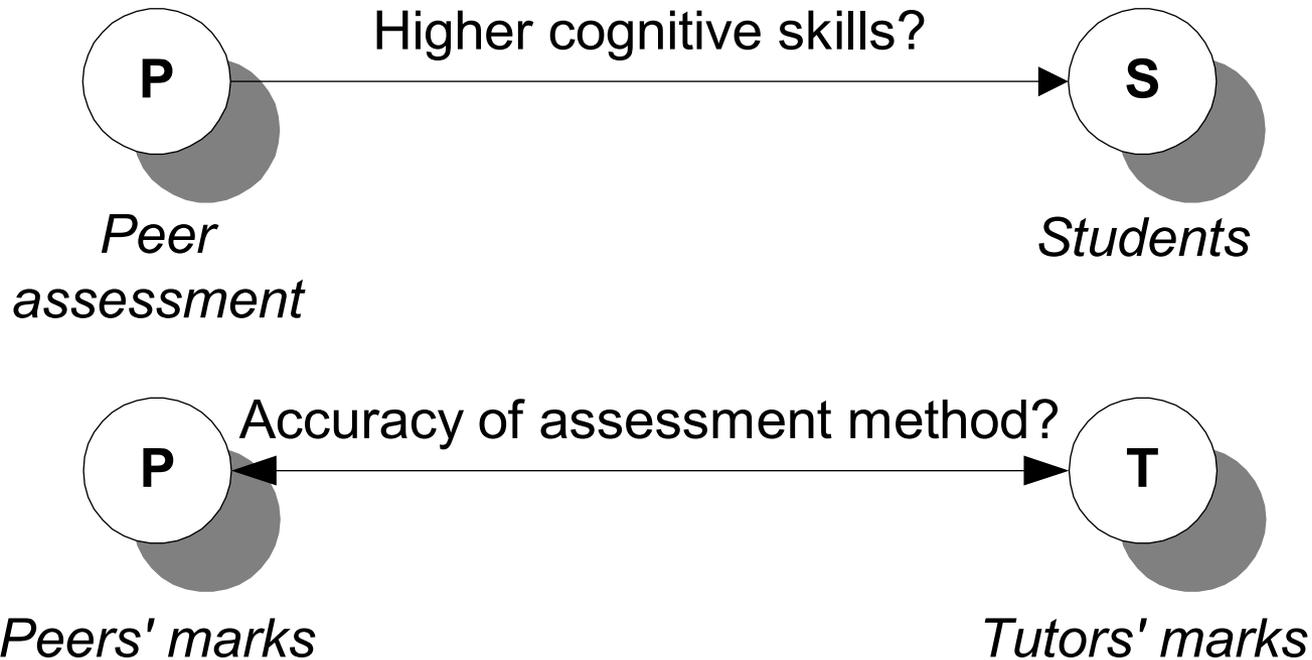




# Benefits

- Students have opportunities to **compare and discuss** about what constituted a good or poor piece of work
- When marking, students **realise mistakes** that they had made in their own answers
- Encourage the students to **reflect** when providing feedback

# Research Questions



- Does peer assessment enhance higher cognitive skills in a programming course?
- Can peer assessment be an accurate assessment method in a programming course?

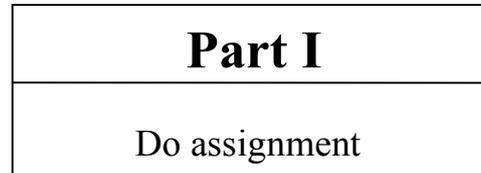
# Experiments

- The peer assessment investigation was performed on 213 first year undergraduate students
  - enrolled on a first year UNIX programming module.
- During the process the students marked and provided feedback on 3 consecutive assignments, and
  - each assignment was marked by an anonymized group of 3 students,
  - using a web-based peer assessment system and an anonymous communication tool.

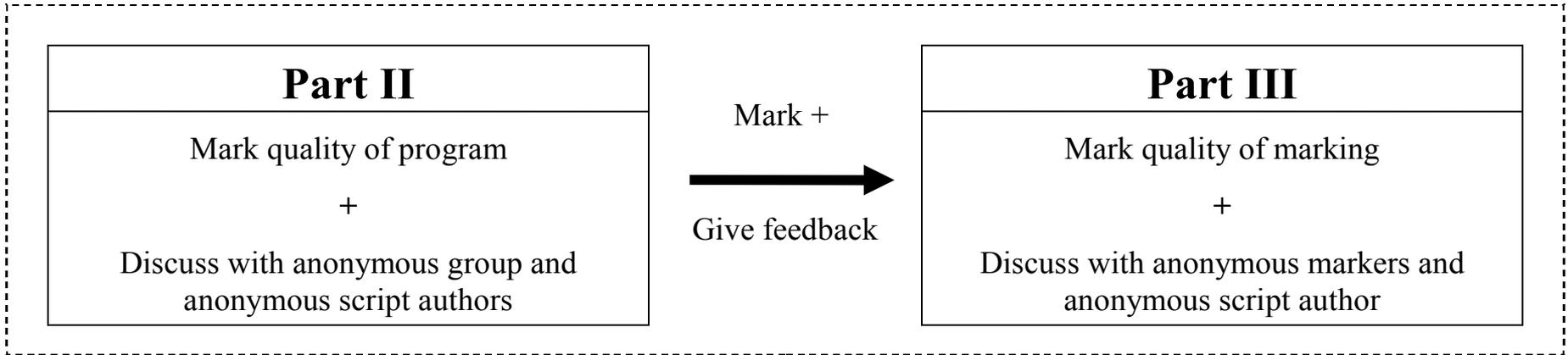
# Experiments

- These assignments were also independently double-marked by two module tutors,
  - in order to provide an expert reference against which the marks awarded through the peer assessment process can be compared.

# Process

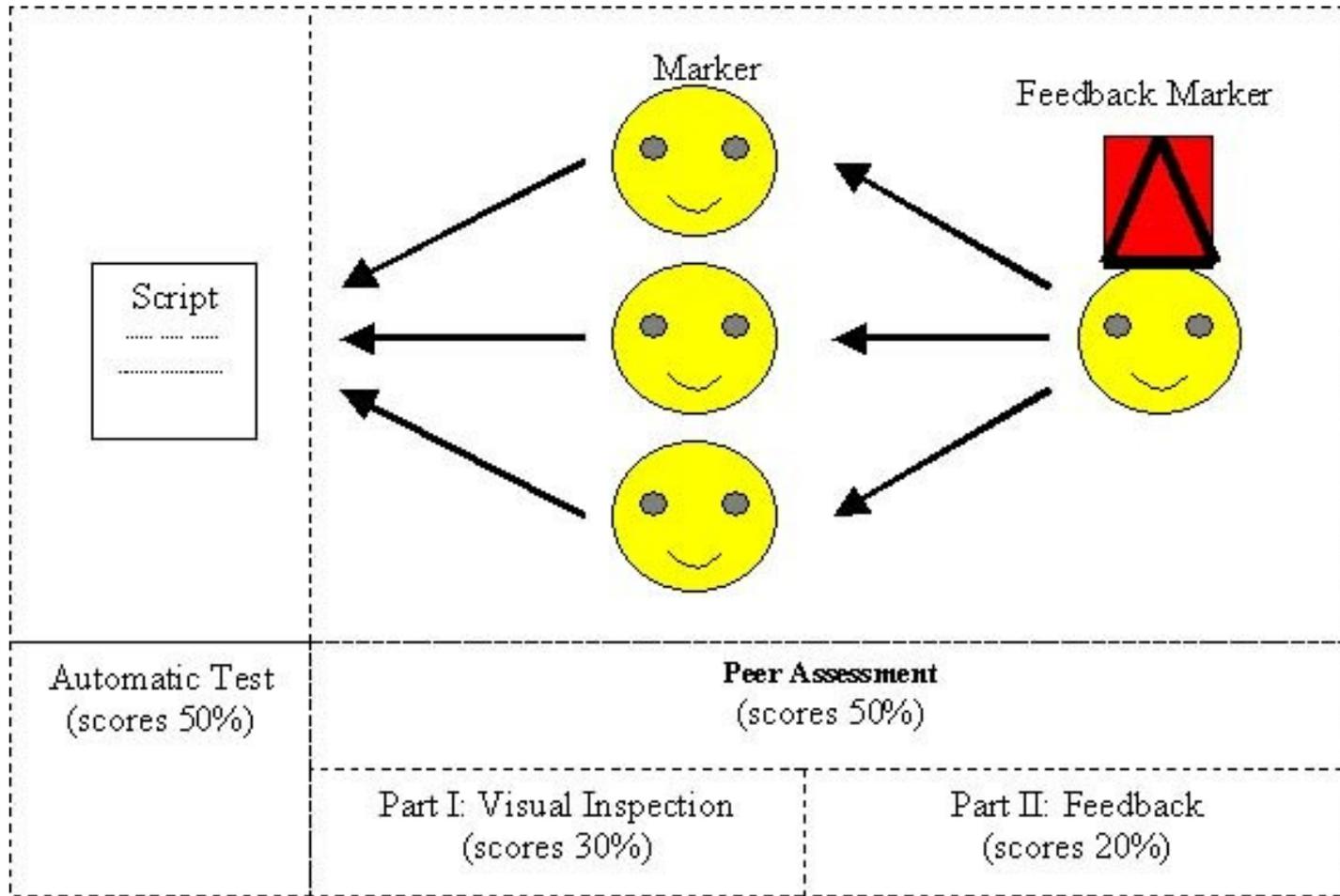


Submit via BOSS system  
(Run ten automatic tests)

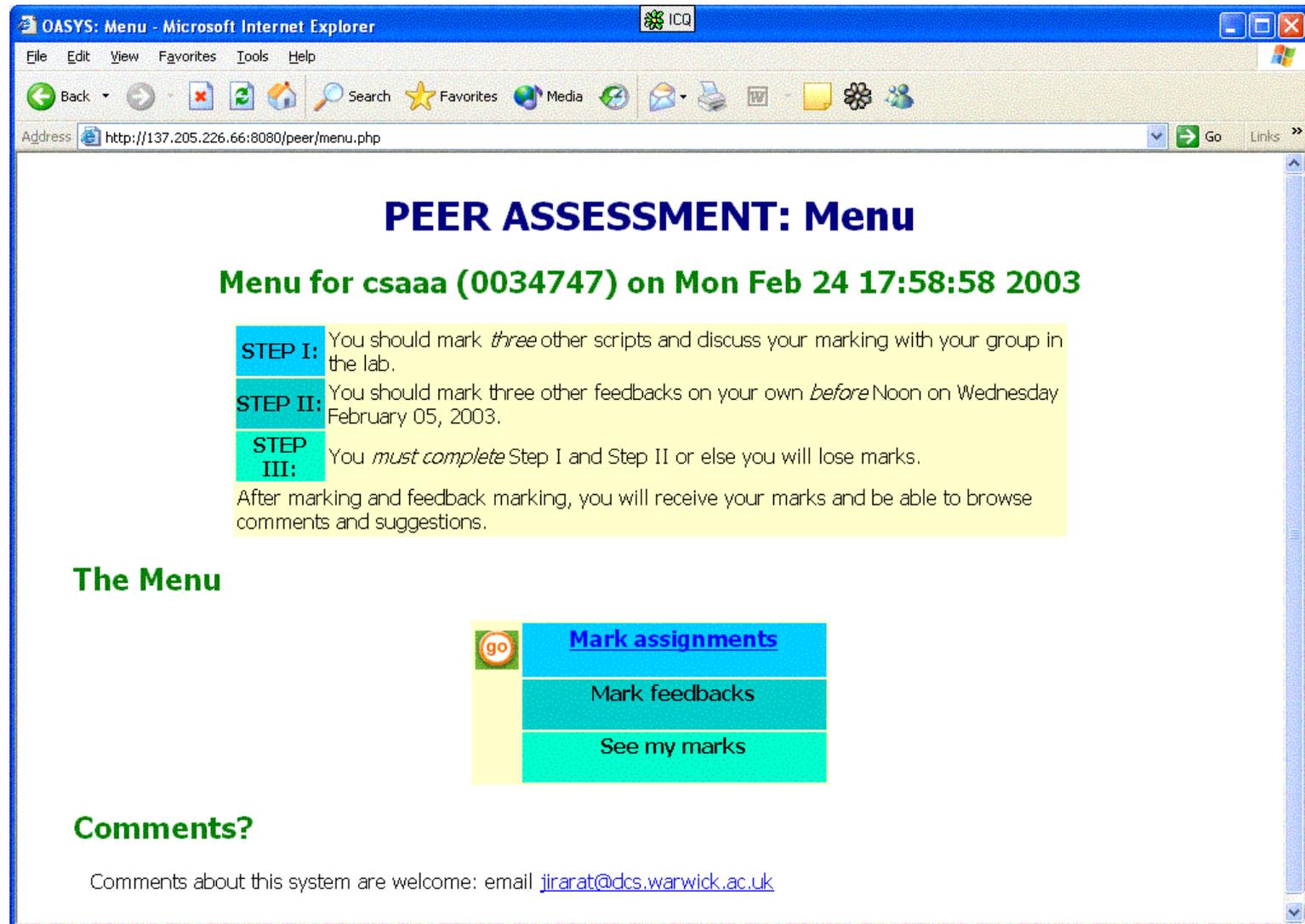


**See results (marks + feedback)**

# Mark scheme



# Web-based peer assessment system



The screenshot shows a Microsoft Internet Explorer browser window with the title "OASYS: Menu - Microsoft Internet Explorer". The address bar contains the URL "http://137.205.226.66:8080/peer/menu.php". The main content of the page is as follows:

## PEER ASSESSMENT: Menu

Menu for csaaa (0034747) on Mon Feb 24 17:58:58 2003

**STEP I:** You should mark *three* other scripts and discuss your marking with your group in the lab.

**STEP II:** You should mark three other feedbacks on your own *before* Noon on Wednesday February 05, 2003.

**STEP III:** You *must complete* Step I and Step II or else you will lose marks.

After marking and feedback marking, you will receive your marks and be able to browse comments and suggestions.

### The Menu

- go [Mark assignments](#)
- [Mark feedbacks](#)
- [See my marks](#)

### Comments?

Comments about this system are welcome: email [jirarat@dcs.warwick.ac.uk](mailto:jirarat@dcs.warwick.ac.uk)



# Step I: Mark assignment

**Step II: Mark quality of marking**

**Step III: See mark**

# Step I: Mark assignment

OASYS: Mark - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Home Search Favorites Media

Address <http://137.205.226.66:8080/peer/mark.php> Go Links

## PEER ASSESSMENT: Mark

**csaaa (0034747) is marking scripts on Mon Feb 24 17:59:28 2003**

[Script1](#) [Script2](#) [Script3](#) [Return to menu](#)

### Script1:

```
#!/bin/bash

FILE="inv.dat" #Sets the default file to inv.dat

NAME=$2      #Sets the second argument to variable NAME as it will be used in the -a option
COST=$3      #Sets the third argument to variable COST as it will be used in the -a option
NUMBER=$4    #Sets the fourth argument to the variable NUMBER as it will be used in the -a option

case $1 in
  -*) #Detects whether the first argument is in fact an option or not. If it is not then the argument is used with grep to
      #print a list of items in inv.dat. If it is an option then the following code is executed

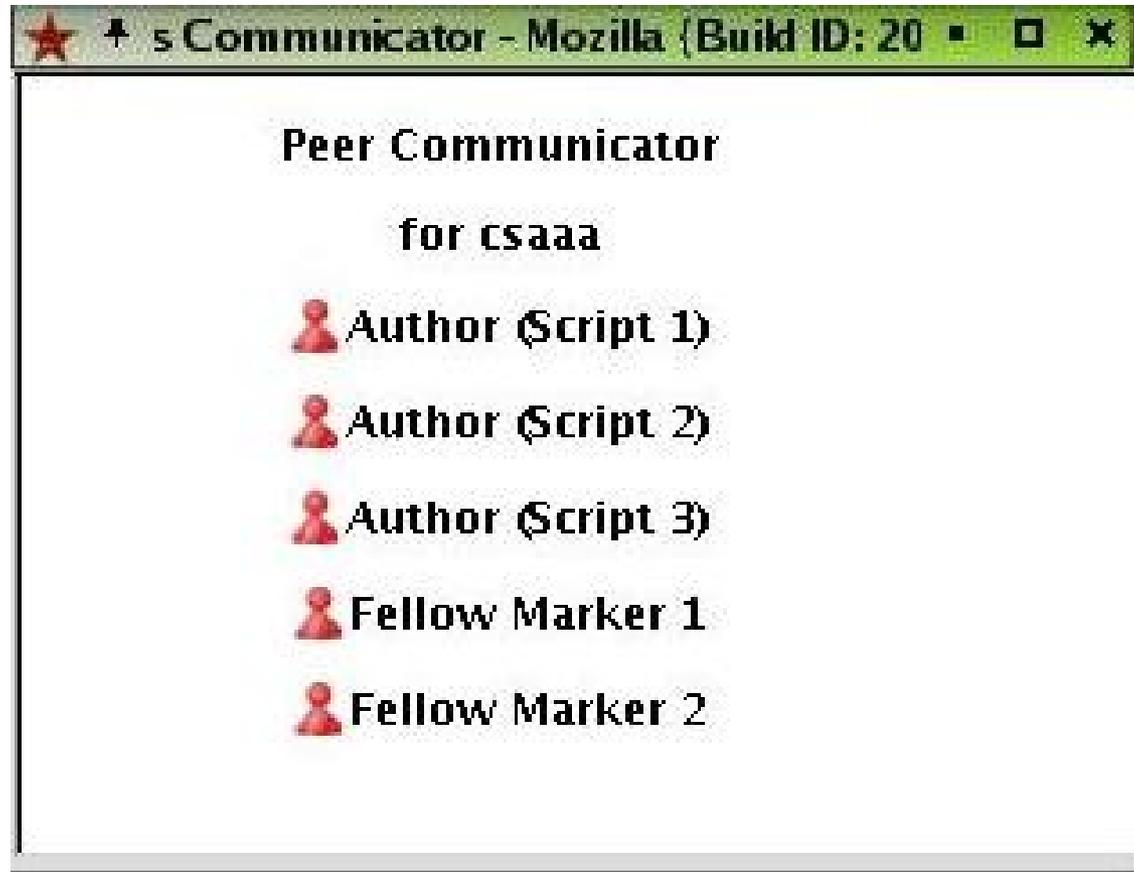
      while getopts hctdf:a OPTIONNAME #getopts detects all options used. f has colons as it uses further arguments
      do
        case $OPTIONNAME in
          f) FILE=$OPTARG; #Sets the argument used with -f to the variable FILE

          h) echo "Usage: inventory -[h]c[t]d [-a name cost number] [-f datafile] [searchstring]"; #Prints out a help on the
            usage
```

**Automatic test results (Score = 75 out of 150)**

**Things to consider**

# Anonymous communication device



# Marking Criteria

OASYS: Mark - Microsoft Internet Explorer

File Edit View Favorites Tools Help

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Address http://137.205.226.66:8080/peer/mark.php

Go Links >>

**My marks:**

Please mark the above assignment by answering *all* of the following questions, and take sometime to comment on why you have awarded these marks in the suggestion textboxes. If this is done properly you will receive an additional 60 marks for your assignment.

<a href="#">Readability</a>	1. Are there appropriate comments?	<input type="radio"/> No <input type="radio"/> Partial <input checked="" type="radio"/> Yes ( <input type="radio"/> unmarked)
	2. Is the code indented helpfully and consistently?	<input type="radio"/> No <input type="radio"/> Partial <input checked="" type="radio"/> Yes ( <input type="radio"/> unmarked)
	3. Do the variable names make it clear what they are used for?	<input type="radio"/> No <input type="radio"/> Partial <input checked="" type="radio"/> Yes ( <input type="radio"/> unmarked)
<a href="#">Suggestions</a>	<ul style="list-style-type: none"><li>* The comments are clear and easy to understand.</li><li>* Same indentation style has been used throughout the script, different indentation levels have been used.</li><li>* Variable names are descriptive</li></ul>	
<a href="#">Correctness</a>	4. Does the code give the correct output?	<input type="radio"/> No <input checked="" type="radio"/> Partial <input type="radio"/> Yes ( <input type="radio"/> unmarked)
	5. Does the code handle errors appropriately?	<input type="radio"/> No <input checked="" type="radio"/> Partial <input type="radio"/> Yes ( <input type="radio"/> unmarked)
	6. Does the program finish with the correct exit status?	<input type="radio"/> No <input checked="" type="radio"/> Partial <input type="radio"/> Yes ( <input type="radio"/> unmarked)
<a href="#">Suggestions</a>	<ul style="list-style-type: none"><li>* -f option doesn't work properly, output should have been sorted alphabetically in some cases, typographical mistake in the help message displayed caused failure of the 'help message' automatic test</li><li>* More descriptive error messages should have been given</li><li>* Exit status doesn't seem to have been considered</li></ul>	
<a href="#">Style</a>	7. Have appropriate utilities been selected, so as to simplify the code?	<input type="radio"/> No <input type="radio"/> Partial <input checked="" type="radio"/> Yes ( <input type="radio"/> unmarked)
	8. Is the program well structured?	<input type="radio"/> No <input type="radio"/> Partial <input checked="" type="radio"/> Yes ( <input type="radio"/> unmarked)



Step I: Mark assignment

**Step II: Mark quality of marking**

**Step III: See mark**

# Step II: Mark quality of marking

OASYS: Mark Feedback - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Home Search Favorites Media Print Mail

Address http://137.205.226.66:8080/peer/markfeedback.php#top

...this would mean someone running the file could not send the errors to a file which could

<a href="#">Style</a>	7. Have appropriate utilities been selected, so as to simplify the code?	<input type="radio"/> No	<input checked="" type="radio"/> Partial	<input type="radio"/> Yes	( <input type="radio"/> unmarked )
	8. Is the program well structured?	<input type="radio"/> No	<input type="radio"/> Partial	<input checked="" type="radio"/> Yes	( <input type="radio"/> unmarked )
	9. Is the program written so it is easy to follow what it is doing?	<input type="radio"/> No	<input checked="" type="radio"/> Partial	<input type="radio"/> Yes	( <input type="radio"/> unmarked )

[Suggestions](#)

The code for doing the operations such as -c are small, compact and simple which is good. The code for reading in the arguments is long and difficult to understand. It is searching the arguments for a pattern and checking if the letters for the options are in there. This means the code is large as it has to check for all different ways of entering values such as -ct, -c -t, -c -ta etc, and to add new options means to add a

Peer Communicator  
for csaaa

- Marker 1
- Marker 2
- Marker 3
- Script author

**My marks:**

Please mark the quality of the marks given by the above marker by answering *all* of the following questions.

<a href="#">Readability</a>	1. Are the suggestions in the READABILITY section relevant and well explained so they are useful to the student?	<input type="radio"/> No	<input type="radio"/> Partial	<input checked="" type="radio"/> Yes	( <input type="radio"/> unmarked )
<a href="#">Correctness</a>	2. Are the suggestions in the CORRECTNESS section relevant and well explained so they are useful to the student?	<input type="radio"/> No	<input checked="" type="radio"/> Partial	<input type="radio"/> Yes	( <input type="radio"/> unmarked )
<a href="#">Style</a>	3. Are the suggestions in the STYLE section relevant and well explained so they are useful to the student?	<input type="radio"/> No	<input type="radio"/> Partial	<input checked="" type="radio"/> Yes	( <input type="radio"/> unmarked )

[Suggestions](#)

For the 'Non-existent data file' automatic test, the script doesn't give the correct exit status and therefore, the mark awarded by the marker for Q.6 is not justified. Else, the comments and suggestions given by the marker seem to be appropriate and helpful.

Submit marks    Reset to original



Step I: Mark assignment

Step II: Mark quality of marking

**Step III: See mark**

# Step III: See mark

The screenshot shows a Microsoft Internet Explorer browser window with the title 'OASYS: See my mark'. The address bar contains the URL 'http://137.205.226.66:8080/peer/seemark.php'. The main content area displays the following information:

**Automatic test results (Score = 75 out of 150)**  
**Things to consider**

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**My overall mark:**

<b>Automatic test score(full score=150)</b>	<b>75</b>
<b>Peer assessment score</b>	
<b>Part I: Visual Inspection(full score=90)</b>	
Scores given by Marker1	75
Scores given by Marker2	80
Scores given by Marker3	65
Average score: Part I	73
<b>Part II: Feedback(full score=60)</b>	
Scores given by Feedback Marker1	60
Scores given by Feedback Marker2	60
Scores given by Feedback Marker3	60
Average score: Part II	60
<b>Total peer assessment score</b>	<b>133</b>
<b>Net Total score(full score=300)</b>	<b>208</b>

**Marking calculations**

# Monitor marking

http://137.205.226.66:8080/peer/monitor.php - Microsoft Internet Explorer

File Edit View Favorites Tools Help

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Address http://137.205.226.66:8080/peer/monitor.php Go Links >>

## PEER ASSESSMENT: Monitor

**csaaa (0034747) is monitoring scripts on Mon Feb 24 17:46:53 2003**

Standard deviation Absent marker Absent feedback marker

**Standard deviation** Recalculate

Script ID:  Monitor

No	Group	Name	University no	User name	Script ID	Automatic test score (out of 150)	Peer assessment score (out of 150)	VI score (out of 90)	Feedback score (out of 60)	Penalty score (out of 60)	New Feedback score (out of 60)
1	A1				100038	120	132	77	55	0	0
2	A1				100132	90	107	52	55	0	0
3	A2				100298	90	123	63	60	0	0
4	A2				100340	120	140	80	60	0	0
5	A2				100474	90	125	65	60	0	0
6	A3				100510	90	118	68	50	0	0
7	A3				100530	120	118	68	50	0	0
8	A3				100742	120	103	48	55	0	0
9	A4				100806	120	117	67	50	0	0
10	A4				100830	105	120	65	55	0	0

# Monitor Anonymous Communication

The screenshot shows a Mozilla browser window titled "Admin Page - Mozilla (Build ID: 2002052918)". The address bar contains the URL "http://ip-115-80-dhcp.dcs.warwick.ac.uk:8080/peer3/search.php". The browser's menu bar includes File, Edit, View, Go, Bookmarks, Tools, Window, and Help. The toolbar features Back, Forward, Reload, Stop, Search, and Print buttons. The page content begins with a "Welcome csaaa" heading, followed by a SQL query: "SELECT fromid, toid, group\_no, timestamp, body as message FROM messageLog WHERE ((1=0) OR (body LIKE '%am%') OR (body LIKE '%call%') OR (body LIKE '%CBS%') OR (body LIKE '%CMS%') OR (body LIKE '%col%'))". Below the query are search filters: "Words: am, call, CBS, CMS, col" with a "Search for Words" button, and "To ID: [ ] From ID: [ ]" with a "Find Conversation" button. The main content area displays a list of messages, each starting with a sender ID, recipient ID, group number, and timestamp, followed by the message body. The messages include questions about variable assignments and script indentation, and responses explaining the use of \$usercode and marking script indentation. The browser's status bar at the bottom shows "Document Done (0.299 secs)".

Admin Page - Mozilla (Build ID: 2002052918)

File Edit View Go Bookmarks Tools Window Help

Back Forward Reload Stop  Search Print

Home Bookmarks The Mozilla Organiza... Latest Builds

## Welcome csaaa

```
SELECT fromid, toid, group_no, timestamp, body as message FROM messageLog WHERE ((1=0) OR (body LIKE '%am%') OR (body LIKE '%call%') OR (body LIKE '%CBS%') OR (body LIKE '%CMS%') OR (body LIKE '%col%'))
```

Words:  Search for Words

To ID:  From ID:  Find Conversation

[485658 said to 517908 \(group 12\)](#) on 2004-01-08 11:42:22:  
why do you set a variable x = 1 in some of your if statements??

[972330 said to 376547 \(group 14\)](#) on 2004-01-07 12:31:36:  
could u explain what the 3rd line of ur program is doing?  
what is 'whoami'??

[584334 said to 682820 \(group 15\)](#) on 2004-01-07 09:11:36:  
Hello, I was just wondering from line 69 onwards why you have used csuzzz instead of \$usercode, could you please explain your method of using

[584334 said to 690400 \(group 15\)](#) on 2004-01-07 09:10:20:  
For script 1 I have spoken to Mike Joy and I am going to Mike and I am going to mark the indentation as being inconsistent. Was just wonderin

[584334 said to 690400 \(group 15\)](#) on 2004-01-12 14:12:50:  
Seen as though we only have to mark one script was just wanting to share the view that I think the marking is relatively good however I can't

[584334 said to 807963 \(group 15\)](#) on 2004-01-07 09:10:30:  
For script 1 I have spoken to Mike Joy and I am going to Mike and I am going to mark the indentation as being inconsistent. Was just wonderin

[690400 said to 584334 \(group 15\)](#) on 2004-01-08 16:32:10:

Document Done (0.299 secs)

# Results

## PEERS vs. TUTOR MARKING

Comparison of total marks	Comparison of individual marks based on marking criteria	Comparison of comments quality
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## MARKING WITHIN A GROUP (PEERS)

Consistency of group marking	Comments quality from students with a wide range of abilities
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## STUDENTS' RESPONSE ON ACCURACY OF PEER ASSESSMENT

Useful comments	Satisfaction with marks	Comfortable in assigning marks
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# Results

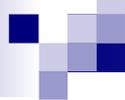
- Peer and tutor marking are compared,
  - using from an analysis of the total marks, the details of each mark awarded, and comments made according to the marking criteria.
- Marks within individual groups are also analysed to find out the consistency of group marking, and
  - the marks from students with different abilities are compared.
- In addition to the analysis of both peers' and tutors' marking, questionnaires and interviews were used
  - to ascertain how satisfied students were with their marks, together with their opinions regarding the marking and the feedback they received.

# Descriptive statistics of tutors' and peers' marks in 3 assignments

		Range	Minimum	Maximum	Mean	SD
Assignment1:	Peer marks	82.00	17.00	99	77.86	16.79
	Tutor marks	50.50	23.50	74	60.97	10.80
Assignment2:	Peer marks	81.00	18.00	99	84.27	12.46
	Tutor marks	79.00	9.00	88	77.77	10.16
Assignment3:	Peer marks	48.00	52.00	100	85.95	8.83
	Tutor marks	46.50	39.5	86	77.90	5.92

# Descriptive statistics of tutors' and peers' marks in 3 assignments

- In this experiment the average of the peers' marks is higher than the average of the tutors' marks
  - 17%, 7%, and 8% in assignment 1, 2 and 3 respectively.
- The difference between the average marks decreased from assignment 1 to 3
  - because students had experience in marking from the first assignment.
- They knew exactly what the markers were looking for and they learned more about how to mark properly



# Relationship between marks given by the tutors and by peers

- The Pearson correlation coefficients in the 3 assignments are positive and substantial ( $r > .60$  and Sig. (2-tailed) = .000).
- There was the strongest positive relationship between the peers' and the tutors' marks
- When the marks given by tutors are high; the corresponding marks given by peers are also high.

# Objective and subjective question type in marking criteria

Marking Criteria	Question type	
	Obj.	Subj.
1. The number of comments	√	
2. Helpfulness of comments		√
3. Appropriate indented code		√
4. Appropriate variable/ function names		√
5. The program meets the specification	√	
6. Appropriate code handles errors	√	
7. The program finishes with an appropriate exit status	√	
8. Appropriate utilities have been selected	√	
9. Good program structure		√
10. Easy to follow what the program does		√

# Objective and subjective question type in marking criteria

- These results are supported by the following comment on marking criteria from a tutor
  - who found that the subjective questions are difficult to mark consistently compared to the objective questions.

*“The marking criteria I found the most difficult were those which were **subjective** such as ‘helpfulness of comments’, and ‘easy to follow what the program does’. It is not possible to mark such a large number of scripts all in one go, so **maintaining consistency in the subjective criteria across all scripts can be challenging**. Marking criteria such as ‘the program finished with an appropriate exit status’, ‘the program meets the specification’, and ‘appropriate utilities have been selected’ are much more **objective and therefore easier to mark in general, and also to mark***

# Conclusions

- The qualitative and quantitative analyses above suggest that
  - peer assessment is an accurate assessment method for a programming course.
- Most students were actively involved in the learning process,
  - were satisfied with marks given by their peers, and accepted that the comments from peers were useful.
- The marking in this peer assessment process was possible
  - because the system provided automatic test results, marking guidance and an anonymous communication tool.

# Conclusions

- Students became familiar with the assessment process, and what is required to be achieved,
  - and as they practiced their marking, their confidence increased.
- These results suggest that the web-based peer assessment system can be used to promote deep learning,
  - and to develop students' professional skills by requiring them to make evaluative judgements and provide specific feedback on other students' work

# Eight published articles

- *Computer support of effective peer assessment in an undergraduate programming class*, Journal of Computer Assisted Learning, 24(3), pp. 217-231 (2008)
- *The Evaluation of Students' Marking in Web-Based Peer Assessment of Learning Computer Programming*, ICCE2004, Australia, November 2004.
- *Web-based Peer Assessment System with an Anonymous Communication Tool*, ICALT2004, Finland, August 2004.
- *Using Web-based Peer Assessment in Fostering Deep Learning in Computer Programming*, EISTA'04, USA, July 2004.
- *Effective Peer Assessment for Learning Computer Programming*, ITiCSE2004, UK, June 2004.
- *Aspects of Web-based Peer Assessment Systems for Teaching and Learning Computer Programming*, WBE2004, Austria, February 2004.
- *Deepening Computer Programming Skills By Using Web-based Peer Assessment*, LTSN, Ireland, August 2003.
- *Web-based Peer Assessment in Learning Computer Programming*, ICALT2003, Greece, July 2003.



Questions?