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*How students learn to program:  
Observations of study time behaviour*

***Pete Thomas  
Carina Paine***

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***Department of Computing  
Faculty of Mathematics and Computing  
The Open University  
Walton Hall,  
Milton Keynes  
MK7 6AA  
United Kingdom***

***<http://computing.open.ac.uk>***



# How students learn to program: observations of study time behaviour

## The Observatory Time Tools (1999)

Pete Thomas and Carina Paine

### Introduction

The Observatory consists of three major components:

- a recorder that records a series of events, together with their time of occurrence, representing a student's interaction with an M206 LearningBook;
- a replayer which replays a recording;
- an analyser that performs a number of analyses on the data contained in a recording.

The Observatory is part of the AESOP project that aims to discover how students learn to program and is associated with the Open University course M206, An object-oriented approach to computing. A description of the AESOP project can be found in [1], and descriptions of the recorder and replayer components can be found in [2, 3].

This document discusses the analyser's time tools: those tools that analyse the timing information contained in an observatory recording.

For each LearningBook that a student works with, the Recorder records a series of events each with a time and date stamp, see Figure 1.

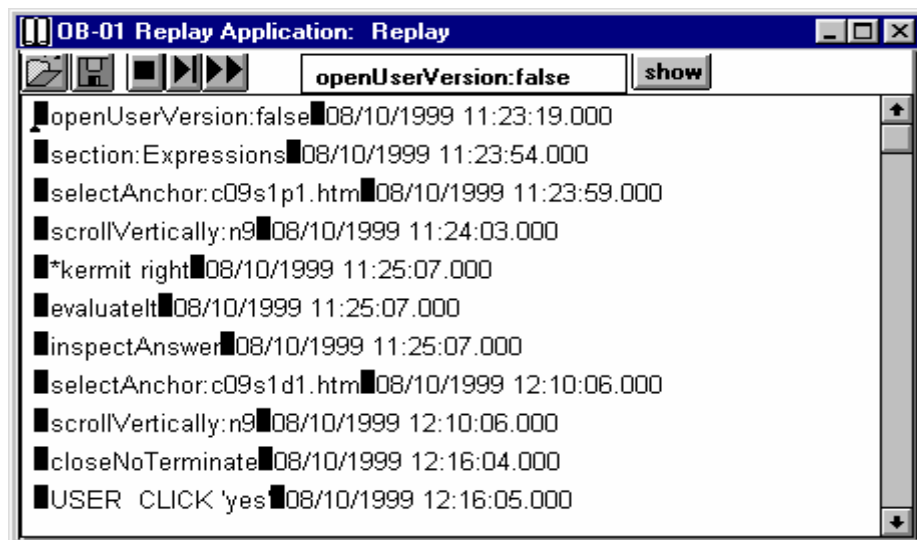


Figure 1 A fragment of a recording (displayed by the Replayer).

It is a simple matter to calculate the *total elapsed time* from the moment the student opens a LearningBook (recorded as the event `openUserVersion`) to the final time the LearningBook is closed (event `User Click 'yes'` following the event `closeNoTerminate`). However, a student can interact with a given LearningBook on several separate occasions, and each time a LearningBook is opened the Recorder simply appends its information to the end of the existing recording. Hence, a single recording holds information about all usage's of a LearningBook, no matter how many times the book was opened or over what period of time.

## The Total Time Tool

In general, the elapsed time of a recording does not correspond to the actual time spent by the student interacting with a LearningBook. A recording will include significant time differences between successive events corresponding to breaks in student activity (there is a 45-minute gap between events inspectAnswer and selectAnchor in the recording shown in Figure 1). Clearly, the time between closing and re-opening a LearningBook is time that the student is not interacting with the LearningBook and can be subtracted from the total elapsed time to give a better estimate of the time actually spent working with a LearningBook. However, it is likely that a student will stop actively using a LearningBook at other times, perhaps to answer the telephone, to make a drink or because of a family interruption. Such interruptions often do not cause the student to close down the LearningBook. Instead the student merely leaves the computer running with the intention of returning to their work at a later time. Such ‘study breaks’ can occur at any point and are observed as long time periods between successive events.

Since the Recorder is non-intrusive, there is no information in a recording which explicitly states why a long gap between two events has occurred. Therefore, the Total Time Tool has been designed to allow its user to specify the minimum size of a gap above which is to be considered a break in student activity. For example, it might be thought reasonable to consider differences between events of more than 10 minutes to constitute a break in study activity. The tool has been designed with a *time difference parameter* that allows its user to investigate the effect of removing all gaps above this level from the total elapsed time. In fact, the tool allows the user to specify a series of time differences to be applied to a given student’s use of a LearningBook.

Table 1 shows the results of removing gaps of different sizes from typical student recordings of the same LearningBook.

Student	Total Time Taken (LearningBook 10)						
	When ‘Time Difference’ is set to:						
	No Break	2 hours	1 hour	30 mins	15 mins	10 mins	5 mins
Student 1	27h59m17s	3h25m33s	2h5m31s	1h26m0s	1h26m0s	1h26m0s	1h26m0s
Student 2	73h48m45s	2h55m15s	1h10m51s	1h10m51s	1h10m51s	1h10m51s	1h10m51s
Student 3	284h34m43s	4h31m59s	2h52m41s	1h44m3s	1h44m3s	1h44m3s	1h18m27s
Average	84h47m31s	2h44m52	1h44m16s	1h28m50s	1h28m50s	1h19m7s	1h11m16s

Table 1 The Calculated study time for a student in LearningBook 10 with varying lengths of break time

Table 1 indicates that, as the time difference parameter is reduced, the time remaining appears to converge to a value that we can take to be a good estimate of the time actually spent actively interacting with the LearningBook. Quite clearly, there can be good reasons why a particular gap should not be considered a break in study. It is quite possible, for example, that the student has reached a point at which he or she needs to examine other course material in order to proceed with the next step in the LearningBook. However, LearningBooks tend to be ‘self contained’ and do not normally require the student to interact with other materials except at well-defined times that we shall discuss in more detail later. In this way, we were able to define the size of a study break and to estimate the total study time of a LearningBook by an individual student. We shall henceforth refer to this time as the *calculated study time*. The data shows quite a wide range of calculated study times.

Figure 2 shows the user interface to the Analyser and, in particular, the *Total Time Tool*.

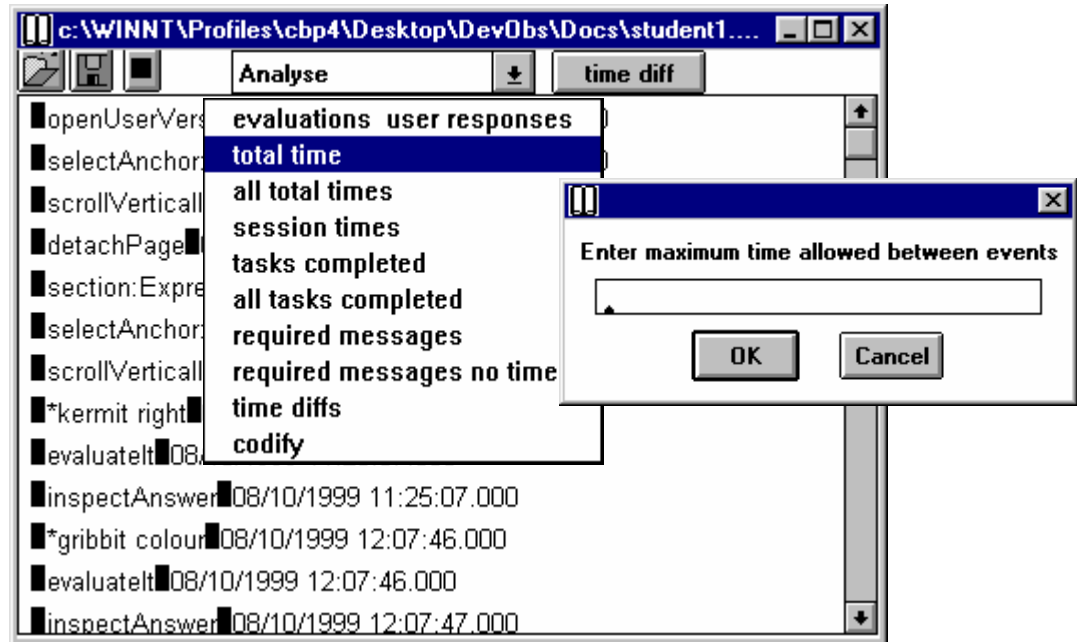


Figure 2 User Interface to the Time Differences Tool

### The All Total Times Tool

The *All Time Tool* is a generalisation of the *Total Time Tool* that enables us to examine the behaviour of all students on a given LearningBook. We have used it to examine the behaviour of students over a number of LearningBooks, and have concluded that a time difference of 10 minutes yields the most consistent view of what constitutes a break in study.

The calculated times spent by students working on a particular LearningBook, having made allowance for study breaks of 10 minutes or more, have been compared with the time that the course team expect a student to spend working on that LearningBook as illustrated in Table 2. The conclusion is that students spend significantly less time on studying the LearningBook than recommended by the course team.

Learning Book	No. of Students	Time Taken		
		Recommended Time	Average Time Taken	%
09	6	4h	2h 20m 38s	59
10	8	4h	1h 19m 7s	33
12	9	1h	1h 25m 58s	143
13	14	4h	1h 14m 25s	31
14	14	4h	1h 35m 28s	40
15	15	2h	0h 49m 44s	41
16	16	3h	1h 40m 8s	56

Table 2 Average calculated study time compared with recommended time set by course team.

On average, students spent 58% of the recommended time studying a LearningBook.

## The Session Times Tool

A closer examination of the results provided by the *All Total Times Tool* reveals that all students do not complete all the work in a given LearningBook and taking an average of the calculated times as a measure of student activity is not wholly useful. However, a LearningBook is made up of a collection of sessions, which means that a more refined view of student behaviour is one in which sessions are examined rather than a LearningBook as a whole.

Since the recordings identify when a particular session is entered and left, it is a straightforward matter to perform the same sorts of analyses on sessions as were carried out on LearningBooks. For example, Table 3 shows typical data collected from LearningBook 13. The times given are those calculated with the *Total Time Tool* having set the 'time-difference' to 10 minutes. In this LearningBook, all students in the sample made an attempt at all the sessions.

Student	Total Time Taken (LearningBook 13)		
	Session 1 (Practicals 1 - 6)	Session 2 (Practicals 6 - 10)	Session 3 (Practicals 11 - 12)
Student 1	0h29m50h	0h17m37s	0h9m40s
Student 2	0h28m38s	0h12m35s	0h17m41s
Student 3	0h39m19s	0h24m32s	0h12m53s

Table 3 The calculated study time for each session in LearningBook 13

In this LearningBook there are three sessions and the range and average times spent studying each session are shown in Table 4. The total number of students in the sample was 14.

Session	Minimum time	Maximum time	Average time	Standard deviation
1 <sup>1</sup>	12m11s	48m3s	35m3s	10m50s
2	5m31s	45m12s	22m28s	9m24s
3	5m6s	44m36s	15m41s	10m15s

Table 4 The range and average calculated study time in each Session for students in LearningBook 13

The figures show that there is still a wide range of times taken for each session, but the average seems a good measure of overall activity given the small standard deviation that is similar for all three sessions.

The amount of work to be done in each session is different. To measure the amount of work, we looked at the number of tasks<sup>2</sup> the student is asked to do in each session. The number of tasks in LearningBook 13 is shown in Table 5.

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<sup>1</sup> The data excludes one student whose calculated study time was so much greater than all the others that it appears to be anomalous.

<sup>2</sup> A precise description of what constitutes a task is given later.

<b>Session</b>	<b>1</b>	<b>2</b>	<b>3</b>
Number of tasks	40	16	10
Average time per task	52.6s	84.3s	94.1s

*Table 5 The number of tasks in LearningBook 13*

The LearningBook from which the above data was taken is atypical because, in most cases, students do not tend to complete all sessions. Data taken from LearningBook 9 shown in Table 6 illustrates the variation.

<b>Student</b>	<b>% of Tasks Completed</b>
1	92.77%
2	32.53%
3	86.75%
4	92.77%
5	90.36%
6	85.54%
7	25.30%

*Table 6 The percentage of tasks completed in LearningBook 9*

Most students attempt most tasks, but few do everything. Tables 7, 8 and 9 show the variation in LearningBook 9 that is more typical of general student behaviour.

<b>Session</b>	<b>Minimum time</b>	<b>Maximum time</b>	<b>Average time</b>	<b>Standard deviation</b>
1	29m36s	1h28m7s	53m50s	21m44s
2	0	59m57s	20m20s	22m19s
3	0	46m49s	22m30s	21m1s
4	0	52m39s	28m16s	24m32s

*Table 7 The range and average calculated study time in each Session for students in LearningBook 9.*

<b>Students</b>	<b>Total Time Taken (LearningBook 9)</b>			
	<b>Session 1</b> (Practicals 1 – 6)	<b>Session 2</b> (Practicals 7 - 9)	<b>Session 3</b> (Practicals 10 - 15)	<b>Session 4</b> (Practicals 16 - 21)
Student 1	33m54s	13m59s	23m16s	21m49s
Student 2	1h8m4s	0	0	0
Student 3	35m34s	0	0	0
Student 4	58m37s	22m50s	46m41s	52m39s

*Table 8 The calculated study time for each session in LearningBook 9*

Session	1	2	3	4
Number of tasks	30	15	21	17
Average time per task	1m47s	1m22s	1m4s	1m39s

Table 9 The number of tasks in LearningBook 9.

An interesting fact emerged from this work: some students repeat some sessions. In some cases, students revisit a session in order to complete it, in other cases they repeat some of the tasks. Whether this latter action is by accident or design remains to be discovered. However, we speculate that, when a student takes a long break, and closes down the system, he or she will quickly read through sessions already studied in order to reach the part where they had previously reached (if the student remembers to save a LearningBook the system will subsequently open up where the student left-off, otherwise LearningBooks have no memory of where a student has got to). The Session Times Tool has to take this effect into account when analysing the data.

### Elapsed time

The elapsed time for a LearningBook shows that, in general, students interact with a LearningBook in several 'sittings'. That is, they work through a LearningBook over a significant period of time, often several days as illustrated in Figure 10, performing the activities in a number of discrete chunks of time (which we shall call *sittings*).

Learning Book	No. of Students	Average Elapsed Time	Minimum Elapsed Time	Maximum Elapsed Time
9	6	1days 22hours	47mins	3days 1hour
10	8	3days 21hours	18hours 24mins	11days 20hours
12	9	2days 17hours	52mins	12days 23hours
13	14	2days 5hours	1hour 59mins	8days 20hours
14	14	1day 9hours	1hour 5mins	5days 23hours
15	15	16hours	47mins	4hours 1hour
16	16	2days 22hours	1hour 33mins	11days 5hours
20	8	1day 5hours	6hours 43mins	2days 5hours

Table 10 Average elapsed time to study a LearningBook.

We define a sitting as the activity between two breaks. Table 11 shows the number of sittings per student in the early LearningBooks in which, as before, a break is defined as occurring between two successive events that differ in time by more than a specific threshold (the time difference). The results shown in Table 11 correspond to a time difference of 10 minutes.

Learning Book	No. of students	No. of Sessions	No. of sittings	Average Time per sitting
9	6	4	5.3	26m 32s
10	8	5	5.3	12m 58s
12	9	1	3.3	26m 3s
13	14	3	3.9	18m 36s
14	14	3	3.8	23m 17s
15	15	2	2.1	23m 41s
16	16	3	4.6	20m 2s
20	8	1	4	39m 4s

*Table 11 Sessions, sittings and times per sitting across LearningBooks with a time difference of 10mins.*

The table also shows the number of sessions per LearningBook, which correspond quite closely with the number of sittings. The same close relationship between the number of sessions and the number of sittings is also seen in the results where the time difference is set to 5mins and 15mins which indicates that students in general tackle the LearningBooks by working on one session at a time. The average length of sitting (with a 10 minute time difference) works out to be 23mins 47secs. Time differences of 5 minutes and 15 minutes give average sitting times of 17mins 20secs and 29mins 33secs, so we conclude that students are prepared to concentrate on practical activities for around 25 minutes at a time.

It should be noted that students are instructed to read parts of the teaching text in between sessions. The recordings show that students do follow these instructions in that they tend to complete a session in one sitting. A few students take breaks within a session.

## **Conclusions**

The general conclusions about student behaviour are:

1. LearningBooks are studied over several days (average is 3 days) in several sittings (the average is 4.2).
2. The amount of (calculated) study time is substantially different from the time recommended by the course team (on average, students spend 66% of recommended time).
3. The amount of time spent on a LearningBook varies considerably between students.
4. In general, students tend to try the first session and then either give up or complete the whole LearningBook.
5. Very few students do all the tasks set (the maximum from the small sample was 93%).
6. Some students do not attempt the practical activities but go straight to the Discussion.
7. Students on average spend about 25 minutes at a time working on a session.
8. In each period of activity (a sitting) a student will attempt one session.

In coming to these conclusions, we took a time difference between events of more than 10 minutes to represent a break in study.



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