CHAPTER 6

Evidence-Based Learning: Foundations

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This chapter discusses some of the Computers and Learning (CAL) research group's early work, focusing on our attempts to understand learners' practices so that teaching could be adapted to meet learners' needs. The chapter describes and discusses examples of CALRG research from the group's early days to the start of the 2000s. One reason for doing this is to explore the extent to which there has been continuity in the group's work over time. In the chapter we argue that the group's motivation, aims, ethos and overall approach have remained similar during its forty-year existence. The chapter draws on the Beyond Prototypes framework, described in Chapter 1 of this book, to frame some of the discussion, in particular focusing on policy and environment. Analysis of the case studies that led to the development of the framework suggest that Technology Enhanced Learning (TEL) needs to be understood as a 'complex', made up of a series of elements that need to be considered together. The chapter also uses the three themes of the group's first conference to provide an organising framework for the discussion. The three themes from that first conference are firstly, models of learning; secondly, methods for studying learning and thirdly, institutional research.

Introduction

As will be highlighted below, much early CALRG research was experimental, and ground-breaking at the time. While many students are now used to working

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with computers, smart-phones, and tablets, and may have only lived in an era where CAL was always around, it may be useful to remind the reader that 40 years ago most students did not have access to computers, let alone the Internet. For example, only 13% of households in the UK in 1985 had a home computer, and only in 2002 did a majority of households have at least one home computer (Office for National Statistics (UK), 2019) Similarly in an age of ubiquitous connection to the Internet, it seems hard to remember a time when people were not connected. In fact, in 1998 only 9% of UK households had access to the Internet, mostly using a slow telephone modem for those who remember. Only in 2005 did more than half of UK households actually have online access, which is nearly 25 years after CALRG was established. Therefore, some of the case-studies discussed will need to be interpreted in their historical context.

This chapter will discuss some of the research group's work, focusing on our attempts to adapt teaching to meet learners' needs. This will serve to illustrate and document some of the research that has taken place from 1979 to the 2000s. It will also support our argument for continuity in the group's work over time: that the motivation, aims, ethos and overall approach of the group during its forty-year existence have remained similar across the years. In discussing the work, we will draw on three aspects of the Beyond Prototypes framework (policy, environment and funding), and will also refer to the three themes of the group's first conference to provide one organising framework for the discussion. These three themes are firstly, models of learning; secondly, methods for studying learning; and thirdly, institutional research. The Beyond Prototypes framework developed by Scanlon et al. (2013), has been described in the first chapter of this book. The case studies that led to the development of the framework suggest that Technology Enhanced Learning needs to be understood as a 'complex', made up of a series of elements that need to be considered together, as represented in Figure 1 (Scanlon et. al., op. cit.) and reproduced in Chapter 1. In this chapter we will illustrate how the elements of the complex have been applied by the CALRG in our research into our students' learning and trying to meet their needs.

Models of Learning: a cognitive science approach to understanding the learner

As noted in the introductory chapter, during its first decade much of the CALRG's work was in the area of cognitive science. There was a strong interest in applying this to the OU context through considering how instruction could be designed to help improve student performance, so the relationship with teaching was strong. Alongside this was an interest in theory development, e.g. understanding how problem solving skills were developed. And again as described in the introductory chapter, one focus was on developing understanding of learners' practices through collecting student protocol data.

One example of this approach is Jones's doctoral research on novices learning programming (Jones, 1993). Four different programming languages in use at the OU were investigated, including high level and low-level programming languages. The first example is of learning SOLO: an AI programming language designed by Eistenstadt (1982, 1983), to introduce Open University cognitive psychology students to Artificial Intelligence as a tool for modelling human cognition. The aim was to make it easy for the user to get the system to do what they wanted it to without getting tangled up in trivial spelling and syntactic errors. SOLO was designed so that such unproductive errors could be trapped thus optimising productive interaction. The main component of SOLO is a language for manipulating a relational data-base, containing facilities for inserting descriptions into the database and for pattern matching against descriptions already in the database.

Eisenstadt (1982) explains the motivation behind SOLO in greater detail and also the project that included a "six year period of design, implementation, testing, and iterative re-design of a programming language, user-aids, and curriculum materials for use by Psychology students learning how to write simple computer programs" (Eistenstadt, 1982, p.1).

Thirteen participants took part in the SOLO case study, all of whom were studying the cognitive psychology course and had agreed to come into the OU psychology laboratory when they reached the part of the course where they were starting to learn SOLO.

The participants in the OU laboratory worked through the instructional materials in the SOLO book. They sat in a room on their own to work and were recorded talking aloud about what they were doing – the researcher would go in from time to time and ask how they were getting on. The task that students were engaged in was working through the instruction book and they reached the first activity that required them to produce some code, the so-called ASSESS problem. This problem was described in the course booklet as follows:

> *"Define your own procedure called ASSESS which prints out UNHEALTHY if someone (the node to which it is applied) either drinks whisky, on the one hand; or else if that person* ***both*** *smokes cigarettes and drinks beer. Using the NOTE procedure, add some descriptions of your own to SOLO's database, and try out your ASSESS procedure to get it working properly. You must decide for yourself how you are going to represent "drinks whisky" etc. in the database."* (Eisenstadt, 1983, p56.)

Some further context will be helpful to make sense of the protocol data. The SOLO primer which participants worked through provides two particular examples to illustrate how flow of control works in SOLO which is described in a section entitled 'Sequencing of programs'. (Eisenstadt, 1983, p.54). These examples are referred to as the 'weakassess' and 'strongassess' procedures.

So what I did was to combine the weakassess and strictassess type programs here, so, here we've got line 10 if drinks whisky, print unhealthy and exit. If absent continue. …
That's the weakassess model.
The next two takes part of the strictassess model, so...: somebody has to smoke cigarettes and drink beer to be deemed unhealthy, so therefore line 20, check somebody smokes cigarettes if absent print healthy
I didn't know if it was right to do healthy and unhealthy, - it doesn't specify that.
So, if present continue and it goes to line 30, check drinks beer, if present print unhealthy because by definition if it's got to drinks beer it's had to have been smoking cigarettes as well. If absent continue and then at line 40 print healthy.

Figure 6.1: an example of protocol data from one of the students, Jane.

These examples are referred to by Jane, one of the participants, as she works on defining the ASSESS problem. Figure 6.1 shows part of Jane's explanation of working on the ASSESS procedure. She drew on examples in the book – e.g. referring to the 'weakassess model' here, and indeed she worked it out correctly.

Other students had more difficulties. These were particularly apparent when they were studied learning a different kind of programming language – an assembler language. This is a level of programming languages where there is a strong correspondence between the program's statements and the architecture's machine code instructions.

This study by Jones (1993) indicated the importance of data which provided information about how students interacted with and acted on the text, and the extent to which the design of instructional materials supported their learning. For some of the analysis programs were approached and viewed as a collection of plans, and this helped to identify the extent to which learners identified (or did not) and used (or did not) appropriate plans. For a researcher and teacher to observe directly how students react to materials that have been written, or technologies that have been developed is a very powerful experience.

A different, later approach to observing learners' behaviour and interactions with computers was the establishment of the data capture suite, many years later when more sophisticated technology could be deployed but with a similar aim. This was to observe and capture detailed learner interactions with media – although by this time the CALRG group was focussing on students' interactions with computers rather than text. One report is by Blake and Scanlon (2003) who used video data to analyse collaborative learning in what became known as the 'data capture suite'.

Learning design has developed considerably since the early work. The next chapter charts the development of the OU learning design initiative and discusses current research into the relationship between learning design, student behaviour, satisfaction, and performance. However, like the early work, there is still an emphasis on detailed information about student interactions with course materials.

In undertaking the observation work carried out in the data capture suite, Blake and Scanlon's overall enterprise was to the investigate *"the usefulness of technology-mediated collaborative problem-solving as part of an ongoing research programme."* (Blake and Scanlon, 2003, op. cit., p5.) For this series of studies, the emphasis had shifted away a little from The Open University's students, although the authors note how the work is associated "*with a desire to improve the experience of learning for our students*", Blake and Scanlon, 2003, p.5. They also refer to their use of the CIAO! Framework, developed within the CALRG for evaluating CAL, and how it draws on a variety of sources, using both qualitative and quantitative approaches (Jones et al., 1999). In evaluating student use of computers, particularly collaborative learning, they argued for the need to observe students interacting with the educational innovation, and also note Issroff's holistic approach (Issroff, 1995) which in addition to recording interactions emphasises the importance of affective measures. Issroff et al., (1994) analysed students' collaborations over a number of sessions and the results showed developments over time. In their overview of this work Blake and Scanlon (op. cit., 2003, p.6) advocated the use of video data: *"Examining the interactions that students have with computers and with each other requires observational data, preferably supported by video data".*
They note that the advantages of such an approach include:

- Its relative objectivity.
- That analysis can be carried out collaboratively by more than one researcher.
- Its use for either or both qualitative and quantitative data.
- That considerable amounts of data can be stored and analysed relatively easily by video-analysis software.

The data capture suite was developed to enable video capture of interactions and combined video data records of each participant with a synchronous record of their computer screen.

This approach was used to investigate a range of problem solving and learning tasks including: teenagers learning the laws of momentum (Whitelock and Scanlon, 1996), children learning about the phases of the moon (Whitelock et al., 1996); adults learning applied maths (Smith et al., 1989), and healthcare professionals using CoMET (Concept Modelling Environment for Teachers) to investigate the educational potential of a concept-based toolkit (Alpay and Giffen, 1998).

One study (Scanlon et al., (2000) investigated the problem-solving behaviour of pairs of adults working on a statistical problem. As in the earlier studies, protocol data was gathered, but additional video data made it possible to observe the subjects' non-verbal gestures. The video provided evidence about the degree of certainty with which the participants put forward their suggestions or solutions to each other and also recorded their reactions to their partner's suggestions. In comparison, a verbal protocol does not always contain clues about these behaviours. This example is part of a larger database with which the group explored the value of videoconferencing and eye contact during remote problem-solving. The study established that pairs who communicated with video which enabled eye-contact were more successful in their problem solving.

Later work, often led by CALRG research students, included an investigation of how newer technologies (newer at that time) might be employed for identifying learners' attention, recording real-time writing and sketching, and analysing multiple data feeds in an integrated way (San Diego et al., 2012). This was a study of learners' interactions with multiple representations to illustrate the advantages and disadvantages of digital approaches to collecting, coordinating and analysing observational data. In these investigations detailed gaze videos were obtained and were able to indicate the paths as well as 'fixations'. This allows researchers to study participants' attention in detail and how it changes over time (see San Diego and Aczel, 2007).

Other research used protocol analysis again combined with a more quantitative approach as a way of observing students using software via the internet (Hosein et al., 2007), thus providing remote observation. In this approach, students used a remote application facility on their own computer to connect to the researcher's computer: they were then able to interact with this computer and use software on it. Audio and video data, mouse clicks and keyboard entry were captured. A quasi-experimental design was used for collecting mainly quantitative data but by adding on talk-aloud strategies, interviews and videoing, qualitative data was also collected. As the researchers noted, this approach to understanding students' use of software for problem solving is not limited to studying students in a particular setting but to any student connected to the Internet in an environment where rich qualitative and quantitative data can be collected.

These studies, where there is an emphasis on the detailed analysis of interaction among learners, can be seen as having a learning analytics focus, although that field had yet to emerge.

Evaluating CAL programs: institutional research

Collecting protocol data was one method for studying student learning, which as noted above, was used over a long period of time. Other approaches were taken in the evaluation work that the CALRG conducted, and this is discussed in this section.

Early evaluation work in the CALRG was on understanding student use of particular CAL programs including CICERO, (Jones and O'Shea, 1982); Works Metallurgist, (Blake et al., 1996); MERLIN, CALCHEM and EVOLVE (Scanlon et. al., 1982). These CAL offerings were developed in response to student needs or challenges. For example, the CICERO CAL tutorials were a way of providing diagnostic feedback and additional help to students. The aim was to understand student behaviour and improve teaching. It is important to note that as courses were often in place for eight years or more, and the main component was printed text, it was not possible to make changes to the text following student feedback. However, it *was* possible to make changes to the CAL programs.

The evaluations aimed to understand the extent to which students used such CAL; benefits and challenges; how they used them and how the programs might be improved. Two case studies will illustrate the CAL evaluation studies, the first one conducted was the CICERO evaluation (Jones & O'Shea, 1982). After each case study summarising the research we will offer some brief reflections.

Case study 1: Tutorial CAL in the early 1980s

The first study focused on tutorial CAL: (Jones & O'Shea, 1981; 1982). The main aim of these programs was to provide diagnostic feedback, remedial help, and revision aid. The particular tutorial CAL program evaluated in this study was called CICERO, and first used on a psychology course in the Educational Studies faculty: "Personality and Learning", in 1977. Note that this was *before* the establishment of the CAL research group – and was one of the first, if not the first, evaluation studies carried out by the CALRG – motivated by a desire to understand more about student use, or lack of use, of CICERO.

CICERO was available at study centres across the four nations (where tutorials were held), and there was a less interactive postal version too. Study centres were not open all the time, so students needed to check that they would be open, and once there they would be using the tutorial via a terminal.

For each tutorial, diagnostic questions relating to a specific block of the course were sent to students to answer at home; the answers provided information about students' conceptual strengths and weaknesses related to the specific objectives of the block and course. These answers were taken to the study centre, the program accessed, and the answers typed in. Further questions might then be asked and according to the answers, advice and remedial help would be given. A 'postal' version was also available providing advice based on the students' performance on the diagnostic questions. The student would receive a printout a few days after posting the answer form.

Use of the system on three courses was rather low and dropped during the course of the academic year, so it was decided to evaluate the use on one course – the interdisciplinary course Biological Bases of Behaviour where 4 CICERO tutorials replaced 4 computer marked assignments. The study aimed to find out why students used or failed to use the tutorials and their beliefs about the educational benefits and practicalities. As the tutorials were optional, introduced no new material, and covered only a selected part of the course, there was no attempt to establish their educational effectiveness. The methods used consisted of an initial questionnaire; a questionnaire built into interactive tutorials and sent with postal tutorials; interviews with students and staff at summer school; final questionnaire to follow up answers to earlier open-ended questions and tutor questionnaires. Usage figures from the computing service records were also available.

Once students could access the tutorials the majority were satisfied and found they met their expectations, but the number of users fell rapidly throughout the year. What put students off? We found (as in many OU studies): an instrumental approach to this optional study; a fear of secret assessment; fear of using computers and embarrassment at the possibility of making mistakes in front of other students. Hence we asked about these issues in the final questionnaires and 22% (out of 100) reported 'bad computer experiences'. The most prevalent bad experience was difficulty in access; of these the most frequently reported were logging in difficulties; 12% (of 543) reported they were nervous of using the terminals and 13% (again out of 543) talked about embarrassment. Only a small percentage (16%) intended to definitely use CICERO again – the main obstacle was travelling and using it at the study centre. We ended up with a Chinese box of barriers, where each access issue is framed within the next: access to terminal (layer 1); access to program (2); quality of program and integration with the course. So students needed to negotiate a number of barriers, or layers, before engaging with the course tutorial itself. We noted that the real breakthrough would be in providing home access, and indeed the personal computing policy, described next, was set up many years later to provide such access.

Reflections on case study 1

Looking back at this study across nearly forty years, five elements struck us. Firstly, at a time when nearly all the focus of educational technology was on cognitive factors, affective issues were noted – students were concerned about secret assessment; fear of using computers and embarrassment at the possibility of making mistakes in front of other students. Secondly, in terms of 'analytics', although no sophisticated records of use were available we did have usage figures available from the computing service records. Thirdly, the barriers were such that many students did not use the tutorial CAL – or they did not persist in using it – hence there was little feedback that fed back into the design of the programme. Fourthly, the approach taken in tutorial CAL (diagnostic multiple-choice questions) was a forerunner of computer-based assessment that developed significantly later especially in the science faculty. Finally, in an elementary way we were able to include some built-in evaluation (e.g.the questionnaire at the end of the tutorial). The next section describes the university's response to the barriers to access that were found in this and in many other CAL evaluations: the personal computing policy.

The home computing policy evaluation project

As noted in case study 1, there were difficulties with accessing computers from study centres. Even so, use of the terminal access system expanded throughout the 1970s. It should be noted that most of the use was by students for whom access was a requirement. For example, from 1970, students on the mathematical foundation course were required to spend around five hours online to the mainframe computer. During that period, similar students in traditional universities were also using computers through online, time-shared terminal access but the equipment was usually in computer laboratories on campus. By 1980, students on 35 courses were using the OU system for some aspect of their study. This included computing courses, and courses began experimenting with various 'standalone' microcomputers at summer schools. Hence, Jones et al., (1993), referring to a period around the late 1970s, and the difficulties of access noted that: *"despite these problems, student computing at a distance was a success and there was pressure to expand"* (p.42).

This led to the development of the "Open University's Home Computing Policy" that both required students (on certain courses) to acquire their own computers and supported them in doing so. This was a large-scale innovation, affecting 17,000 students by 1992. Running alongside the policy development was a research project that evaluated the policy. The book describing this educational evaluation explains that *"We set out to investigate the effects of requiring students on particular courses…included in the policy, to make their own arrangements for acquiring a microcomputer"*. (Jones et al., 1993, Preface). In terms of the TEL complex, taking account of the ecology of practices and technical content is particularly salient in the Home Computing Policy (HCP) project.

The 'success' of student computing at a distance meant an increase in the number of courses that wanted to include some form of computer provision. Although terminals and the mainframe were updated, the university system could not even cope with student demand from existing courses. Courses began to experiment further with using 'standalone' micros at residential schools: the evaluation of one such experiment is reported in case study 2 described below. Different course teams adopted different solutions, including different computers, as there was no leading market standard or computer at the time. For example, one low population course found funds to buy computers in order to loan these to students. Student demand was also increasing: many students wanted to use a computer for their OU study – or were already using one and wanted guidance on what to use or buy:

> *"By 1984 the university was considering the feasibility of specifying one particular machine which would primarily serve the computer science courses, but would have the capacity to handle a variety of software applications"* (Jones et al., 1993, p.44).

In the end the direction taken was to define the equipment according to compatible software, thus developing a home computing policy which specified an operating system. A core policy team oversaw the project, and a large team of academics and staff from the student computing services collaborated with senior university managers to conduct studies of students' and tutors' practices, to run pilot projects, and capture student and tutor experiences. Twenty different reports were written over the period of the project (1988 – 1991); reporting on diverse aspects including the use of computer-mediated communication (Mason, 1988), computing on mathematics courses and tutor use of the home computing facility more generally (Kirkup and Dale, 1989). The pedagogical context of the university was particularly important given the OU's commitment to openness and accessibility. The wider context of what computers were available at the time was clearly crucial – and a policy was needed that could respond to changes in the wider environment. That was achieved by defining software requirements rather than hardware.

The development of the policy and its evaluation is a good example of the Beyond Prototypes model of the TEL complex in practice. The key features of the project that determined its success were:

- Commitment to the policy at a senior level in the OU, underpinned by the importance of providing access to computers which, given student and course team demand, was argued as being crucial to the university's core business.
- The idea originated with academic staff and 'spread upwards' (Jones, Kirkup and Kirkwood, 1993, p.148) so had strong champions who prepared the ground and developed the argument. This and the previous point show the importance of context.
- Key players included the chair of a very large population course, which needed access to a computer for the preferred design of the course to work.
- The policy aimed to provide affordable and accessible access for our students in line with the OU mission: 'to be open to people, places, methods and ideas' and to 'promote…educational opportunity and social justice'.
- Alongside a history of collecting evidence about our student learning lay a commitment to evidence-based research: so the evaluation findings had a ready audience in appropriate university committees.
- The evaluation took a broad approach. Issues highlighted by the evaluations included the students' social and physical context; issues of access and equal opportunities; teaching practical computing work at a distance; the design of learning materials and institutional support.
- The OU saw itself, and was viewed externally, as innovative.

One chapter in Jones et al.(1993) devotes itself to an analysis of why and how the university adopted the HCP. This adds an additional dimension to the features above, which is the political and economic context of the 1980s when a period of recessions and contraction began. There were a number of challenges to the institution, and the OU felt particularly under threat, and needed to find ways to cut production costs. The policy had powerful and persuasive champions who carefully laid the ground and made preparations for the final debate at the university's senate. The chapter concludes (see Jones et al. op. cit., p.148) that "one of the most interesting aspects of the HCP was that it was an idea that spread upwards from the academic staff who argued it through formal and informal channels in such a way that ownership of the idea became diffused throughout the institution."

Case study 2: Works Metallurgist (1996)

"The Works Metallurgist", (Blake et al., 1996), was an interactive tutorial designed to teach interpretations of phase diagrams and the Lever Rule (a method of calculating percentage of solid and liquid in an alloy at a given temperature from a phase diagram) to Open University students. It was developed for "Materials: Engineering and Science", a second-level course which ran from February until October and included a residential summer school. Course evaluations had shown that students had difficulties in interpreting and applying phase diagrams, and the program was specifically developed to help students in this area. It was in a game format, and students were given job titles ranging from Applicant for Apprentice Metallurgist to Works Metallurgist, according to their performance.

Students used the CAL programs during their laboratory work. The program had been designed for individual use, but students mainly worked in the laboratories in pairs, and usually chose to use the program in pairs too, and to discuss their answers with each other before typing them in. Three computers were also provided in the student hall for use at any time. The aim was to answer the following questions:

1. How do students use the program?
2. Does the software contribute to learning? and if so what do students learn?
3. How can it be improved?

The participants were 540 students who studied "Materials: Engineering and Science" in 1995. The researcher attended two weeks of residential school (out of seven) and conducted observations and interviews. The students had reasonable familiarity with computers, and were given a questionnaire, attitude scale, and knowledge pre-test, along with the evaluation disk (a special version of the program that recorded some usage information).

Forty-four sessions were observed; both in the laboratory and the student hall where the program was also available for use during summer school. Where appropriate the students were asked to supply reasons for their answers. The observer tried to minimize the disturbance to students' natural progress with the program, but was occasionally asked for help with the tasks, and this was used as an opportunity to ask probing questions. A two-stage questionnaire was given to 60 randomly selected students, where stage 1 asked about previous OU courses, study of phase diagrams, and the students' computing background. This provided an attitude measure and a knowledge pre-test.

Stage 2 concerned the efficiency of the program, the quality and nature of students' interactions with it, their difficulties, their opinions of the program, and general comments. These 60 students were given a special version of the program which recorded usage information and were asked to return the disk after five weeks. This evaluation disk enabled us to see how much time students spent on the program, which sections took most time, and how much improvement in their understanding they made in that limited time. To measure their learning achievement students completed a knowledge pre-test along with the first part of the questionnaire, and they were tested again (using the same questions) after they had finished working with the program. Four more short questions covered the important concept of phase. Formal and informal interviews were conducted in the laboratories and in the computer suite in the student hall. Tutorials related to phase diagrams were also attended by the researcher, and students' attendance and activities during the tutorial were observed.

Observations revealed that The Works Metallurgist was the program used most during the 2 summer-school weeks. It was available for sale and most students who saw it decided to buy it, if they had access to an appropriate computer. The observations about its use and popularity were supported by the sales figures. Students reported that the program was very useful, and most could only suggest making minor changes to it. None of the students reported the program as being difficult to use, and they were easily able to use specific features such as Crosshairs, and the Draw Tie Line and Show Labels facilities. Evaluation disks returned showed that they spent a great deal of time using the program, ranging from 12 to 276 minutes with a mean of 128 minutes.

The pre-post test data showed little difference in their knowledge before and after using the program. At that time, we noted that the difficulties in using pre-and post-tests in CAL evaluation were known and documented and that such instruments are not sensitive to the complexity of the learning situation. Data from the evaluation disks showed that the errors made in each section decreased with time. The students also commented that the game-like nature of the program was motivating. We also had data from 29 students who were positive about having learnt from using the program and in particular felt that it had helped them in understanding phase diagrams.

Reflections on case study 2

As in case study 1 we did have usage data for the students that used the evaluation version of the program (but at a very small scale – 60 students). In addition to the questionnaires and interview used in this study as with case study 1, students were observed using the program and students also completed knowledge tests, although the pre-post test data showed little difference in their knowledge before and after using the program – a common result in CAL evaluation.

The main link between this work and learning analytics is that both are concerned with understanding student behaviour and use and improving teaching as a result – but that in our historical CAL evaluations we were focusing on one aspect of a course – the CAL component.

Summary and Conclusions

In this chapter we have described some very early work of the CAL research group, noting the influences on work in the late 1970s and in the '80s from research in cognitive science and Intelligent Teaching Systems. Thus the methods adopted for such work often focused on observations of student learning and collecting detailed data of students interacting with written texts of CAL or of whole models. Earlier studies often used protocol data in the laboratory: in later work, the CALRG 'data capture suite' provided video data of students working collaboratively. The commitment to a fine-grained understanding of student behaviour, use and learning with technology and improving teaching as a result is echoed in today's learning analytics work (see Chapter 7) although of course this focuses on the student experience throughout the course or module.

Major goals of our early work were to develop a better understanding of student behaviour, and to improve instructional design. Also, when the course materials consisted of texts that lasted a number of years, it allowed feedback to inform changes to CAL: this could be changed in a way that print could not. Some elements have persisted through time. One such element, the aspiration to have built in evaluation and data collection, was successful, although this was much more limited in the 1970s and early 1980s.

CAL evaluation: institutional research, was illustrated by two case studies of CICERO (tutorial CAL) and the Metallurgy works. One of the findings in the CICERO evaluation was that affective issues were important – as well of course as the importance of integrating any CAL closely with the course and providing good accessibility.

So, two main strands of work have been identified here; firstly a technology-focused approach influenced by AI and focusing on learner models, and secondly a focus on research that investigated what learners' needs actually are. In both these approaches, the OU was ahead of its time. We are now witnessing a ressurgence of interest in applying AI to education (see, e.g. Luckin and Holmes, 2016) but in 1978 it was unusual to teach AI as part of cognitive psychology. The university was also breaking new ground in researching into its own students: in collecting and analysing usage data of student CAL use, in trying out mixed-methods methodologies, exploring methods of data capture, in detailed analysis of interactions and in considering affect. Some of this research laid the ground for the current work on learning design and analytics which is described in the next chapter.

Some of the lessons learnt from this early work for meeting learners' needs are still valid and really important today:

- It is not possible to meet learners' needs without an understanding of pedagogy and how people learn;
- Context is vitally important and needs to be considered in different ways;
- Affect is very important: emotions such as fear and embarrassment have a significant effect on learning behaviours, yet it is only during the last fifteen years or so that this has been widely acknowledged and become part of mainstream educational technology research;
- Assessing how people learn and how they learn best is challenging because of the nature of the learning situation.

The chapter has also considered a successful institutional innovation – the OU's Home Computing Policy – that was analysed at the time in terms of the economic and political climate, both at a local and wider level. However, the HCP is also a good illustration of the TEL complex in practice. One of the important components of the policy's access that was listed was the commitment to the policy at senior university level. This is not a novel argument or finding, but perhaps the fact that it was also 'bottom-up' and so had ownership amongst academic staff and our associate lecturers is significant.

References

Alpay, L. and Giffen, R. (1998). 'Investigating a concept-based tool to enhance the process of curriculum development: an example for healthcare education', in B. Cesnik, A.T. McCray and J.R. Scherrer (eds), Proceedings of MEDINFO' 98 (9th World Congress on Medical Informatics), Seoul, Korea: IOS Press, 781–4.

Blake, C; Butcher, P; Scanlon, E and Jones, Ann (1996). The Works Metallurgist: an evaluation of a CAL package on phase diagrams. *ALT-J: Research in Learning Technology*, 4 (1) pp. 55–57.

Blake, C. T. and Scanlon, E. (2003). Enriching accounts of computer supported collaboration by using video data. *ALT-J: Research in Learning Technology*, 11(2) pp. 5–13.

Eisenstadt, M. (1982). Design features of a Friendly Software Environment for Novice Programmers, in (Eds. Marc Eisenstadt, Mark T Keane and Tim

Rajan), Novice Programming Environments: Explorations in Human-Computer Interaction and Artificial Intelligence, Routledge, UK.

Eisenstadt, M. (1983). Units 3–4, Cognitive Psychology, Artificial Intelligence project: the SOLO primer. (2nd edition), Open University, Milton Keynes, England.

Hosein, A., Aczel, J., Clow, D., and Richardson, J.T. E. (2007). An Illustration of Students' Engagement with Mathematical Software using Remote Observation. In: 31st Conference of the International Group for the Psychology of Mathematics Education, 8–13 Jul 2007, Seoul.

Issroff, K. (1995). 'Investigating computer-supported collaborative learning from an affective perspective', unpublished Ph.D. thesis, Institute of Educational Technology, Open University, Milton Keynes.

Issroff, K.; Jones, A. and Scanlon, E. (1994). Case studies of children cooperating with computers: a time based analysis. In: Foot, H. C.; Howe, C. J.; Anderson, A.; Tolmie, A. K. and Warden, D. A. eds. *Group and Interactive Learning.* Southampton: WIT Press, pp. 73–80.

Jones, A and O'Shea, T. (1981). An evaluation of tutorial CAL at The Open University: the use of Cicero on SDT286. CAL research group Technical report no. 5. The Open University.

Jones, A and O'Shea, T. (1982). Barriers to the Use of Computer Assisted Learning. *British Journal of Educational Technology*, 13(3) pp. 207–217.

Jones, A. C. and Scanlon, E. (1981). A review of research in the CAL group: A report of the first annual conference, November 1981; Open University, UK.

Jones, Ann (1993). Conceptual models of programming environments: how learners use the glass box. *Instructional Science*, 21(6) pp. 473–500.

Jones, A., Scanlon, E., Tosunoglu, C., Morris, E., Ross, S., Butcher P. and Greenberg, J. (1999). Contexts for evaluating educational software. Interacting with Computers, Volume 11, Issue 5, May 1999, Pages 499–516.

Jones, Ann; Kirkup, Gill; Kirkwood, Adrian and Mason, Robin (1992). Providing computing for distance learners: a strategy for home use. *Computers & Education*, 18(1–3) pp. 183–193.

Jones, A., Kirkup, G., & Kirkwood, A. (1993). *Personal Computers for Distance Education. The Study of an Educational Innovation.* London: Paul Chapman Publishing Ltd.

Kirkup, G. and Dale, E. (1989). Home Computing Evaluation Project. M205: End of Year Report. Home Computing Evaluation Reports, Institute of Educational Technology, Open University.

Luckin, R; Holmes, W. (2016). Intelligence Unleashed: An argument for AI in Education. UCL Knowledge Lab: London, UK.

Mason, R. (1988). The Use of Computer Mediated Communication for Distance Education at The Open University. Home Computing Evaluation Reports, Institute of Educational Technology, Open University.

Office for National Statistics (UK). n.d. *Percentage of households with home computers in the United Kingdom (UK) from 1985 to 2018*. Statista. Accessed June 27, 2019. Available from https://www.statista.com/statistics/289191/household-penetration-of-home-computers-in-the-uk/.

San Diego and Aczel, James (2007). New approaches to researching the pedagogical benefit of representations and interactivity. In: Computer Assisted Learning (CAL '07), 26–28 Mar 2007, Trinity College Dublin, Ireland.

San Diego, Jonathan P.; Aczel, James C.; Hodgson, Barbara K. and Scanlon, Eileen (2012). Digital approaches to researching learners' computer interactions using gazes, actions, utterances and sketches. *Educational Technology Research and Development*, 60(5) pp. 859–881.

Scanlon, E., Jones, A., O'Shea, T., Murphy, P., Whitelegg, E. and Vincent, T. (1982). 'Computer assisted learning', in *Teaching at a Distance Research Supplement no. 1*., pp59–79, Open University, Milton Keynes.

Scanlon, E., O'Shea, T., Smith, R. B. and Joiner, R. (2000). 'Technological mediation of synchronous collaboration: science and statistics in SharedArk and Kansas', in R. Joiner, K. Littleton, D. Faulkner and D. Miell (eds), Rethinking Collaborative Learning, London: Free Association Books.

Scanlon, Eileen; Sharples, Mike; Fenton-O'Creevy, Mark; Fleck, James; Cooban, Caroline; Ferguson, Rebecca; Cross, Simon and Waterhouse, Peter (2013). Beyond prototypes: Enabling innovation in technology-enhanced learning. Open University, Milton Keynes.

Scanlon, E., Blake, C., Joiner, R. and O'Shea, T. (2005). Technologically mediated complex problem solving on a statistics task. *Learning, Media and Technology*, 30(2) pp. 165–183.

Smith, R. B., O'Shea, T., O'Malley, C., Scanlon, E. and Taylor, J. (1989). 'Preliminary experiments with a distributed multimedia problem solving environment', Proceedings of the First European Conference on Computer-supported Cooperative Work (EC-CSCW '89), London, 13–15 September, 19–34. Whitelock, Denise; Scanlon, Eileen and Taylor, Josie (1996).

Whitelock, D. and Scanlon, E. (1996). 'Motivation, media and motion: reviewing a computer supported collaborative learning experience', in P. Brna, A. Paiva and J. Self (eds.), Proceedings of the European Conference on Artificial Intelligence in Education, Brighton: AIED.

Whitelock, D., del Soldato, T., Scanlon, E. and Taylor J. (1996). 'Moons and collisions: how different tasks influence collaborative problem-solving in science using information technology', paper presented at European Conference on Educational Research, University of Seville, Spain.