Space, computers and learning

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SPACE, COMPUTERS, AND LEARNING

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ABSTRACT

This paper aims to provoke thinking about the way people can use computers to learn, the way tutors or instructors can integrate them into their curriculum, and the consequences for the way that the computers themselves are laid out and timetabled. Our experience (Ryan, M., Wells, J., Freeman, A. and Hallam, G. 1996) led us to conclude that though computers radically modify the learning process, they do not replace the tutor. Instead, they change the way that tutor and student interact. By reflecting on the three-way interaction between students, tutors and computers we suggest a theory of the physical space that these occupy, and its consequences for classroom design.

STUDENTS, TEACHERS, AND THEIR COMPUTERS: MULTIPLE ACTIVITIES IN A SINGLE SPACE

We want to provoke University administrators and architects to rethink the way they allocate space for computers, the way access to this space is controlled, and the way the space itself is organised. We want to provoke teachers to think about the way they need to restructure, or re-organise, their contact time with the students when computers are involved.

The core idea we want to explore, which we think is poorly understood among both educators and administrators, is that computers should not primarily be conceived of as a merely open-learning or merely distance-learning resource, but as a flexible adjunct or extension of normal teaching which works best when students actively interact with subject specialists while conducting computer-based assignments, including computer-based assessments.

The *mode* of interaction may be very varied; computer-mediated distance-learning may be regarded as one pole, and open-learning with tutor-marked assignments as another. The crucial point, however, is that in all except the far extreme of self-instructed open-learning learning processes, all three elements are present: tutor, learner, and computer. In assessing the most appropriate organisation of resources, the keyword, therefore, is ‘flexible’.

We suggest this should be the prime consideration when allocating space: it should facilitate flexible interaction between teacher, students, and computers. This three-way interaction requires new, and often radical thinking, about computer layout, scheduling, and access. All three are normally present, and often at one time: tutor, computer, and student. This principle does not inform many current laboratory layouts which indeed, hardly reflect the requirements of student-computer interaction, let alone the added presence of the tutor.

BACKGROUND

The reflection arises from experience we have both had in curriculum revision involving computers as a learning resource, from Alan Freeman’s experience of commercial computer training environments, and from Malcolm Ryan’s experience in computer-mediated communication including distance learning. Our common experience was an EHE-funded project to create a university-wide unit to teach Economics Principles to non-economists (Ryan, M., Wells, J., Freeman, A. and Hallam,

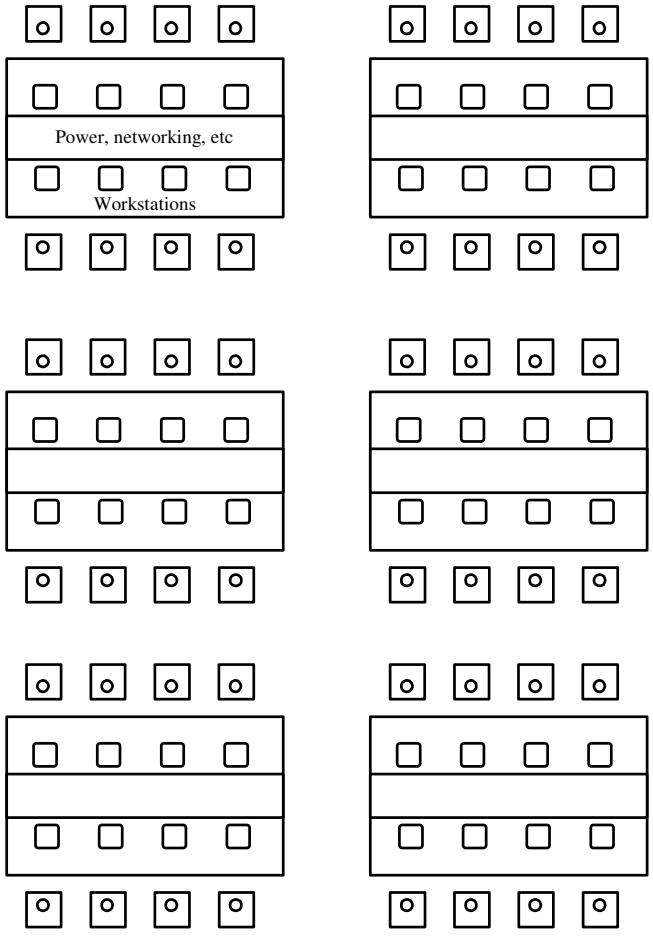
G. 1996). Among other innovations, we made a radical attempt to use computers as a central resource, scheduling one-third of the contact hours as 'supervised computer sessions'. In contrast with many quite unfavourable evaluations of computers as a learning resource for economics students when used in open-learning mode, the responses to this delivery mode were overwhelmingly positive.

THE LEARNING EXPERIENCE FROM HELL

To introduce our ideas, we hope the reader will forgive us some innocent fun. We begin with a caricature of the kind of setup we want to criticise and improve. This is not so untypical of the layout found in the learning environments established by many science-based disciplines, for which the computer is a *specialist tool* rather than a *learning resource*. The kind of setup that results is shown in figure 1

We would characterise such computer laboratory layouts as the *domination of technical form over function*; the prime consideration which determines the layouts is not the purpose to which the computers are to be put, but the technical requirements of placing the computers so that they can be connected to power and networks using as little space as possible.

The result may charitably be labelled the learning experience from hell: it is noisy, hot, cramped, and frustrating. It limits the use of computers essentially to the purely technical function of typing in and printing out.



It is hard to fit the list of defects of such a layout into the same visual space as the layout itself. Students cannot communicate with each other, except their neighbour, with whom they are placed in direct competition for space.

The teacher cannot see anyone at all from any point in the room, since the only students not hidden by machines have their backs to the remaining open space.

Movement is virtually impossible, since the aisle space is designed to the minimal requirements of moving in and moving out. The heat generated by each bench is in excess of 4KW and the noise is equally repressive.

Overhead lighting makes glare unavoidable. Minimal bench space makes it impossible to lay work down except at the expense of severe postural constraints such as having to reach over work to the keyboard.

Figure 1: the sweatshop as learning environment

To grasp the impact of this design the reader might like to consider its consequences for a theatre, church, or a concert hall. It is in fact quite hard to think of collective experiences organised in this

way. A banquet perhaps; though rather antisocial since the computers and benching are above eye level and make an impenetrable visual and aural barrier to communication, and since there is no room for the waiters to deliver the food.

The only activities traditionally laid out in this manner seem to be sewing and pig-feeding. The model is, in fact, that of a sweat-shop: the only consideration is to maximise *machine density*, at the expense of all else.

Though such layouts appear justified on grounds of economy, we would question even this justification, since they are not found in any profit-making enterprise, where the prime consideration is not just the economic use of space but the productivity of the humans that use it, which are a far more expensive drain on resources (average PC cost per year inc. depreciation is about $5,000, average cost of support is about $20,000 and average employee salary is about $40,000 at 1999 levels).

The layout seems to be a unique product of educational institutions, where it arises from the fact that no valuation is placed on the productivity of the learners themselves. It should be clear, for example, that if by reducing the number of computers in a given space by half, the result is to treble the amount of learning which can be accomplished in a given time, then this use of space is more productive and more economically efficient. If, therefore, the outcomes of the learning experience itself were integrated as design criterion into the planning of the computer environment, we think that there are substantial economic gains to be made, over and above the quality of the learning experience itself.

However, a critique of this form of organisation leads to wider reflection: what exactly is the most effective and flexible use of space, if students, teachers and their computers are to share it in a productive learning experience?

FORM AND FUNCTION IN TECHNICAL PROGRESS

It is probably a truism to say that in the history of every technical invention, industrial design is a by-product of the technical form that the invention takes. Only very late in the product cycle does actual human ergonomics seem to become the prime consideration, if at all.

The dream of flying like a bird is a far cry from the actuality of modern mass transport. Trains and planes do not give us wheels or wings; they give us stations, airports, queues, cancellations, disasters and not least, enquiries.

Civilisation seems to go through three stages in its reaction to technical advance. In the first stage, to paraphrase Dr Johnson, although the thing is done badly, it is a wonder it is done at all. In this phase devotees put up with almost anything to experience the wonder of the new. Each new generation repeats this experience. Yesterday's propeller-heads travelled in buses without roofs, trains without heating, and cars without tyres; they used elevators that dashed them to the ground, toasters that exploded, paddleboats that regularly burst into flame, biros that leaked, gramophone needles they sharpened daily, radios which howled, whistled, faded and vanished, televisions like goldfish bowls and mobiles like tanks.

In the second phase, technical form may soften but essentially imposes itself in the name of modernity. The transistor radio made a phenomenal concession to humanity; it allowed itself, if somewhat grudgingly, to be carried. It is hard to overestimate the significance of this development, which opened the epoch of the personal gadget: to the first practical incarnation of the idea, perhaps originating with the car, that the machine should come to the human, instead of the human to the machine.

But the limited adaptability of such products imposes on humans a kind of inverted inferiority complex. The car is most characteristic of this phase. It seems like an extension of the person, but in fact it redefines the person. A person in a car becomes a different person, a road-user,

complete with uniquely urban psychoses such as road-rage and special afflictions that arise only from car use such as crashes. She or he becomes an extension of the car.

This is to some extent because of the limited technical form of the product – despite appearances the car is not a foot extension, because, although personal, it is not of human dimensions. We cannot lift cars, put them in our pockets or fold them away and when we are in them we cannot perform most of the functions which we can when we are outside the car. Perhaps exoskeletal machines of the future will change all this. However there is a second, and more powerful reason, which is that such inventions change civilisation itself, so that in reality, the technical innovation is not so much the car as the system of roads, not so much the radio as broadcasting, not so much the computer as the internet. In this sense, the notion that post-modernity replaced the large with the very small is perhaps misconceived. The machines of which we now form part are not smaller; they are so vast we have lost sight of them.

Modernity therefore embraces and celebrates, in characteristic forms such as futurism, the human limitations of the technical product, not because cars, transistor radios or PCs are in themselves particularly aesthetically pleasing or comformable to human use, but because they are the access points to the transformed civilisation that they have brought about. We are not so much extensions of the car as components of the road system.

It is only in limited, but significant developments as modern clothing, the walkman, or perhaps archetypally, the book, that we see the lineaments of a third phase in which the device itself is re-integrated into human space, and becomes a genuine and obvious extension of humanity, instead of an enforced adaptation of humanity to its own technical limits.

This is perhaps the reason for the most striking feature of the information age: the persistence of the printed word. The paperless office has been proclaimed since the first LEO computer; yet the first thing any student does with an interesting web-page is print it. If, when we design spaces for our computers, we do not provide even the square metreage to lay these pages down, the peace to read them, the light to see them, or the space to discuss them with associates and tutors, then we have not absorbed a very basic truth about what humans are, because we conceive them as extensions of machines, instead of the other way around.

THE TECHNICAL LIMITATIONS OF THE COMPUTER

The PC as it currently exists falls within the second stage as outlined above. Its portability and price just about define it as ‘personal’. It is celebrated and increasingly universalised, not in and for itself, but for the access that it provides to a transformed vision of civilisation, to the theatre of virtuality. In itself it is far from a natural extension of human capability. It is difficult to learn; it imposes unnatural forms of interaction – leading to an entire class of diseases that only arise from these interactions – and actually, it doesn’t do very much, outside of video games. You can’t talk to computers, you can’t wear them, live in them, or eat them, and they don’t even make any of these things easier.

This is exacerbated by the physical form of the computer. Although we should be intensely aware of the potential implications of miniaturisation, the crucial point to be aware of is that the nature of the computer fundamentally restricts and diverts from other interactions. The computer dictates *absorption*, which seems to be characteristic of much second-stage technology. The interaction employs most human organs, some would say all. This in turn cuts a computer user off from communication with all other humans except, paradoxically, in the virtual world of the computer itself.

This is perhaps the most basic point to consider in designing learning layouts involving computers. It is one of the sources of the layout in figure 1: since, it seems, a computer-user requires no interaction with anything except the computer, why waste space on it? The heroes of William Gibson’s *Count Zero*, absorbed in a virtual world that for them has become more real than reality itself, contemptuously dismiss the needs of the body as ‘meat’; this is how the educational

administrator, if she or he is not careful, already treats them. We have the learner, we have the machine: what else matters?

HOW THE COMPUTER MODIFIES THE CLASSROOM

In practice, most learning environments have had to recognise the most decisive novelty of the computer: it interacts. It is for this reason that, in most training environments, space usage has mutated away from the traditional classroom layout. The inverse extreme of figure 1 is the layout of figure 2 in which the computer is treated simply as an *adjunct of the classroom*.

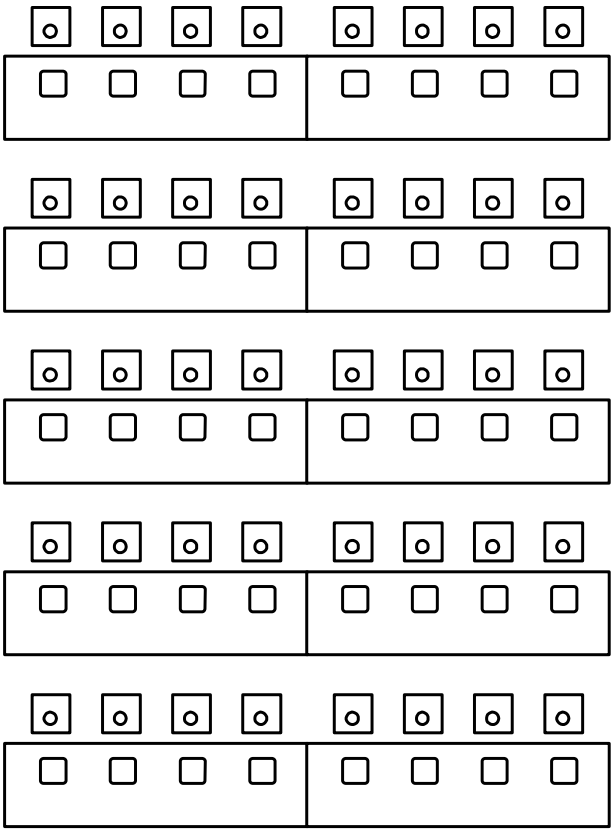


Figure 2: the converted classroom

The layout overcomes the disadvantages of figure 1 in one respect only: the students face the teacher.

But the lecturer faces a constant dilemma; insofar as s/he wishes to talk about what is happening on the computer screen, s/he requires the students both to pay attention to the front of the room, and to watch their screens. Insofar as s/he is talking about something other the computers, they are nothing but an obstruction.

It is precisely because the computer is interactive that it cannot be treated as a simple development of the book or the notepad. One can listen to/watch a lecturer and take notes or even refer to printed pages at the same time; one cannot use a computer at the same time.

The computers become a visual barrier between lecturer and students, which is equally frustrating to those students who cannot see the lecturer over a forest of monitors, and to those lecturers that wish to interact with students who promptly flee into the computer.

There are technical solutions to this though few (notably Littlewoods Training division) adopt them; glass top desks allow computer screens to be placed below elbow level so that there is always direct eye contact. Laptops may also change this aspect of things. But since the fundamental cause of the conflict is the mode of interaction, it expresses itself always in the same way, namely a struggle between the tutor and the learning resource for the attention of the student.

FLEXIBILITY AS A SPACE REQUIREMENT

There are various unique and ingenious solutions to this problem. Our school, for example, modified the layout from hell with headsets so the tutor could talk the students through their interactions. A more radical solution is to internalise the tutor on the screen itself, as a video window.

However, these solutions only peck at the problem: sooner or later, we suspect that curriculum design will be forced to recognise that universality of the computer changes the learning process itself. The biggest impact of the computer is on delivery. It is no longer safe or adequate to suppose that lecturers will interact with students in one of the two standard forms of a fixed lecture

where the students listen to the lecturer, or a fixed tutorial where the lecturer listens to the students. The computer makes it possible – and, increasingly, necessary – to devise learning processes in which students will *alternately* interact with each other, with their computers, and with the lecturer, in the same learning space, whether this space is physical or virtual.

The issue for forward-looking design, therefore, is neither for the computer to dictate to the lecturer, nor for the lecturer to dictate to the computer, but to create the most flexible possible spaces for the innovations yet to come. The difficulty with the standard lecturing solution is that it demands simultaneity. The tutor has to ensure that all students are doing the same thing at the same time, and in this way, imposes on the computer the limitations of the traditional lecture format.

In fact, computers genuinely do facilitate great variety of learning interactions, and in particular they make it possible for the tutor to ensure that everyone, even though they are at different stages of the learning process, can remain active in a mixed-ability cohort. The real requirement of a learning space involving computers, tutors and students is that it should be flexible enough that it can be adapted to all these modes of interaction. In particular, it should facilitate at least the following three modes of interaction in the same space:

(1) simultaneous or lecture-style delivery in which the lecturer or tutor makes a single point, in phase, to every student, possibly presenting it in computerised form (large-scale display or broadcast)

(2) asynchronous or tutorial-style computer-mediated delivery in which each student accesses pre-packaged, short assignments and then interacts either with other students, with the tutor, or both, to reflect on the results

(3) self-instruction with a tutor present as advisor and support, in which the student essentially follows a prescribed course of interactive study, but needs access to the tutor in order to confirm results, receive guidance, and receive assistance.

To this, increasingly, should be added a fourth mode of interaction, computer-mediated distance learning, in which using e-mail and conferencing software such as lotus Notes, students can interact with each other and the tutor entirely through their computers. This may either be in a course that is explicitly designed as a CMC distance learning course, or a natural extension of the classroom. For example, students taking Business Computing for Economists complete an assignment each week in mode (2), which they then e-mail to the tutor for formative assessment.

THE EXPERIENCE OF THE TRAINING INDUSTRY

THE FALLACY OF THE ABSENT TUTOR

The burgeoning computer training industry has long ago turned its back on the idea that the computer replaces the teacher. Today's standard training package consists of

(1) a training facility which isolates clients from external disturbance (many companies send clients on training courses explicitly to remove them from work pressures, which otherwise prevent their employees dedicating enough attention to learning)

(2) a dedicated machine for each client

(3) a package of printed materials and software containing intensive laboratory exercises and, increasingly, simulations

(4) a minimum of one tutor for each twelve students. Usually, twelve students is regarded as the optimum.

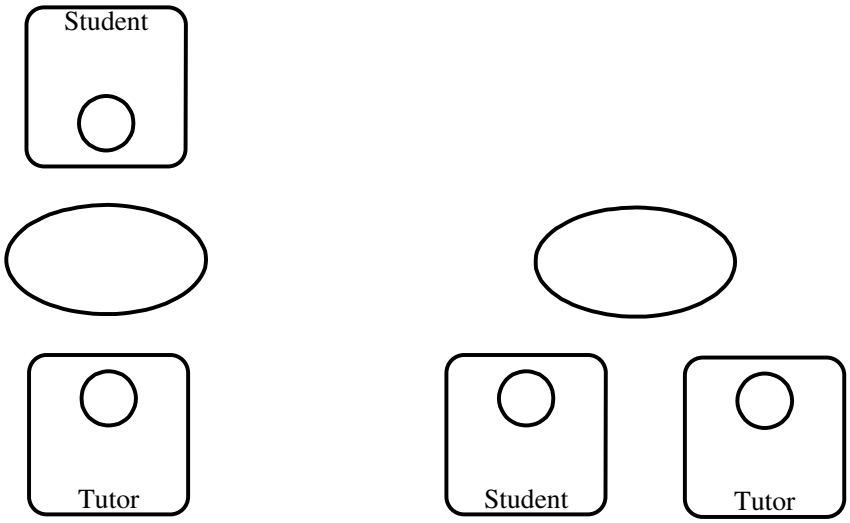
We are not suggesting that today's HE environment can sustain staff-student ratios of 12-1. What emerges from the above, however, is that when learning is packaged as a commercial product,

so that clients purchase what they find to be the best learning experience, they find that it does not work to abolish the tutor. The nature of the learning experience still requires a human intervention; indeed if anything, the computer increases this requirement.

But the computer radically alters the learning experience, as we can see by examining the resources listed above, and considering the types of interaction that arise from them.

TRAINING LAYOUTS

The training industry ten years ago adopted, almost universally, layout 2 above; the computerised classroom. The most basic difficulty that arose was the need for *three-way* interaction between student, computer, and tutor. When discussing what is happening on a student's screen, the key requirement is that both student and tutor should interact with the screen, as figure 3 indicates:



3a: Student interacts with computer and Tutor

3b: Student and Tutor interact with computer

The training industry began modifying the classroom layout by reducing the number of benches and increasing the space between them. The tutor alternates between lecture- and tutorial-style interaction by walking between the central space of the classroom and the benches, and as a consequence must continually interrupt delivery in order to move physically, as well as endless tripping over the wires.

The solution finally adopted, which is to be found in better HE laboratory environments, is obvious but simple: it is to place the students with their backs to the tutor. This seems counter-intuitive since the whole point of lecturing is generally conceived of as obliging the students to look at the tutor and listen at the same time; but this is because simultaneous delivery requires undivided attention to be focussed on the tutor.

Once the key requirement is understood to be flexibility, however, it becomes clear that students can be asked to re-position themselves for those components of delivery that use mode (1); that is, they need rotating chairs. Since (fortunately) these are recognised as a standard component of a laboratory setup, this gives rise to figure 4 below:

This could usefully be the point of departure in the design of computerised classrooms. It is counter-intuitive for the administrator seeking to maximise the use of space, and the lecturer accustomed to traditional delivery. However, practical experience testifies that it is a delight.

The tutor can interact freely with individual students or groups, with the screen as focus of attention, without distracting from other activities; s/he can rapidly change mode to traditional lecturing, simply by asking the students to turn around.

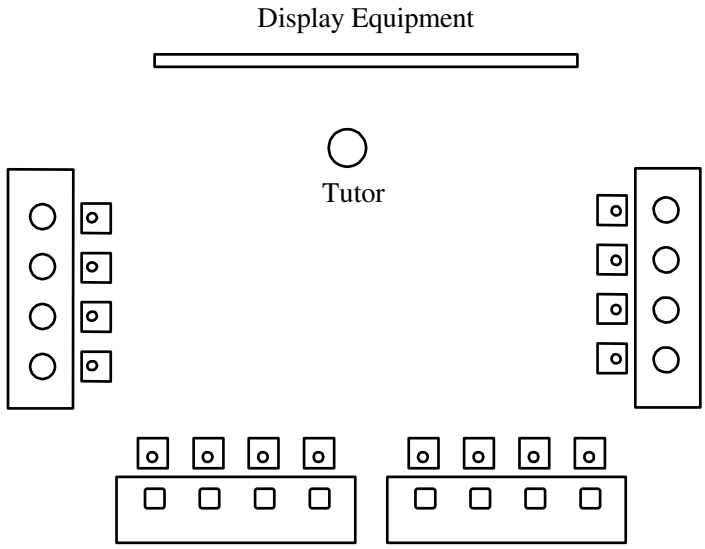


Figure 4: Modern training industry layout

This has the added advantage that the students then break off the interaction with the computer, transferring their attention to the tutor and central visual media.

If lighting is properly designed (low-level around the sides of the room, combined with switchable central lighting focussed on the central media) glare can be almost eliminated, and not least, noise and heat levels are far more acceptable because both are generated at the edge of the room instead of the centre, and with judicious design can be filtered, convected, or conducted away.

REFERENCES

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