Makeshift or Marvellous: Reality or Rhetoric
Are ICT classrooms fit for purpose?

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Abstract

Over a 15 year period the British government will invest £45 billion in capital funding and PFI credits as part of their “Building Schools for the Future” initiative. (Select Committee on Education and Skills, 2007) In 2007-8 alone, the government will spend £6.3 billion upgrading secondary schools. (Design Council, 2007). Clearly this is a significant investment. The aim of this research was, therefore, to determine whether the ICT classrooms in the University of Bedfordshire’s catchment area were already fit for purpose or if they were not, what changes needed to be made. This paper will provide a summary of the findings from this research (Egan, Jefferies & Stockford, 2008) which provided an analysis of the extent to which a sample of Becta’s (2007a) guidelines regarding the design of ICT classrooms were being implemented in a targeted group of schools. Where guidelines were ignored, the researchers set out to determine why this was the case. Ultimately, ICT classrooms can be makeshift or marvellous. Determining “who” and “what” could make this happen was the purpose of this study. The results of this research will, therefore, inform those responsible for funding and designing the ICT classrooms of the future.

Background

Over a 15 year period the British government will invest £45 billion in capital funding and PFI credits as part of their “Building Schools for the Future” initiative. (Select Committee on Education and Skills, 2007) In 2007-8 alone, the government will spend £6.3 billion upgrading secondary schools. (Design Council, 2007). Clearly this is a significant investment yet Greany, in the forward to Higgins, Hall, Wall, Woolner & McCaughey’s (2005) study, commented not only on the paucity of studies in the field (of school design), but worse, that
the research that had been done was predicated on a traditional view of same place, same
time learning. “The danger with this as we set out on the government’s massive and exciting
school building programme is that we will use evidence from the past to inform a very similar
future, when what is needed is a new approach and new solutions for school design to reflect
the changing needs of learning in the 21st century.” (p.3). The aim of this research was,
therefore, to determine whether the ICT classrooms in the University of Bedfordshire’s
catchment area were already fit for purpose or if they were not, what changes needed to be
made.

Research for this study was undertaken over a seven month period from September 2007 to
March 2008 and was funded by Becta. The authors initially conducted a pilot case study in
the academic year 2006-7 and their findings were reported at BERA 2007, (Egan, Jefferies
& Stockford, 2007) These indicated that classrooms, in the main, were not well designed
and often lacked many of the basic requirements for a healthy learning environment. This is
not surprising as the government does not require schools to follow their own advice unless
the schools are new or substantially rebuilt. (Dfes, 2004) This means that the design of ICT
classrooms is mostly left to the vagaries of local decision making and fiscal constraints.

Generally, research on the design of ICT classrooms falls into four categories: 1) the initial
design of the classroom 2) hardware 3) software and finally 4) the overall management of the
system. For example, Sutton, Wait and Benseman (2001) conducted an extensive literature
review covering all four areas. Despite this report being some years old the feedback from
their forums and public meetings is pertinent. “Parents wanted schools to have the most up
to date equipment and opportunities, principals wanted robust management systems while
teachers wanted adequate technical support.” (p. 65) These comments mirror the views of
Tearle (2004) who noted the need for clarity in relation to the roles and responsibilities of
support teams in ICT. She comments, for example, that “a delineation between curriculum
support and advice and maintenance of equipment may prove crucial to the parallel needs of
supporting staff and running a robust system.” (p. 25). It is, however, noteworthy that much of
this research and advice has been ignored. For example, Higgins, et.al (2005) noted, in their
literature review, that “much of what is known about student comfort, particularly in terms of
furniture, has yet to be translated into actual school environments, “ (p.29).

Methodology

Having noted the wide variations in classroom design along with the apparent disregard of
Becta’s guidelines for classroom design. (Becta 2007a; Becta 2007b) the research team
decided to focus on the reality rather than the rhetoric in the second round of data collection.
40 trainees from the University of Bedfordshire’s Applied PGCE (14-19) programme were
asked to collect detailed data on ICT classroom design from an opportunistic sample of partner schools used for trainee placements. The case study reported here consists of an investigation of a total of 113 ICT classrooms in 33 partnership schools that offered placements to the University of Bedfordshire’s PGCE (14-19) trainees. These schools were based in nine counties: Bedfordshire, Buckinghamshire, Cambridgeshire, Hertfordshire, Lincolnshire, Norfolk, Northamptonshire, Oxfordshire and Suffolk. Trainees were provided with digital measuring devices and were asked to provide detailed drawings of ICT classrooms found in their schools. Data was analysed using Becta’s guidelines as a baseline. The research team also conducted semi-structured interviews with an opportunistic sample of Network Managers, Heads of ICT and members of Senior Management Teams and the results were analysed thematically in terms of:

1) Classroom Design and Impact on Performance
2) General Appearance
3) Equipment
4) Management of Resources

Findings

1) Classroom Design and Impact on Performance

The key characteristics identified and analysed were:

a) Shape and Size of the Room

b) Work Space Allocation and Occupancy

c) Environmental Factors (Heat, Light, Ventilation)

d) Acuity and Sight Lines
a) **Shape and Size of Rooms**

Classroom shapes fell into 3 categories:

- **A. Square**
  - 27%

- **B. Oblong Thin Vertical**
  - 56%

- **C. Oblong Thin Horizontal**
  - 17%

The average area of the classrooms observed was 70 m². This fell within Becta's analysis of classroom size, which ranged on average from 50 – 75 m². However, 56% of classrooms observed were oblong vertical in shape (B). This finding was significant as Becta point out that oblong rooms of this shape are the most difficult to teach in. (Becta 2007a.)

b) **Work Space Allocation and Occupancy**

As previously noted, the area of a typical ICT room according to Becta’s findings would be between 50 and 75 m² (Becta, 2007b). Becta does not, however, give occupancy guidelines, although reference to the HSE guidelines (HSE, 2007), suggest that the maximum occupancy, based upon these areas would be 11 – 16 respectively. Tanner (2000) in a discussion of the impact of class size on educational outcomes deduced that if a secondary school classroom is 90 m² in size then occupancy should be between 14 and 15 students.

Analysis of the rooms assessed in our second capacity study, however, provided an average area of 70.02 m², with a minimum of 20.46 m² and a maximum of 184 m². The occupancy for these rooms was 21 and 47 respectively. Based upon the HSE guidelines the maximum average occupancy for the ICT rooms surveyed, should have been 15 students, whereas it was 27; nearly twice the recommended maximum density. Considering the smallest and largest ICT rooms respectively, they had occupancy densities of 4.5 times and 1.1 times the recommended maximum HSE guidelines.
Thus, in this second capacity study which examined 63 ICT classrooms in 17 schools, only <5% (3) ICT rooms complied and they were all located within the same school. Even that school, however, did not comply in terms of occupancy density in all of its ICT rooms. With reference to the other ICT classrooms <10% were within, what might be considered, an acceptable tolerance of 12%, either above or below the HSE guideline (Fig. 1):

![Fig. 1 – Occupancy density and compliance with Becta Guidelines](image)

In addition to classroom occupancy levels, the recommended spacing between workstations is between 1000 and 15000 mm. However, if two pupils are working next to each other this effectively means a 750 mm spacing is needed between workstations. (Becta, 2007b) For the most part, workstations are in series and therefore the spacing is based upon compound sharing.

However, as can be seen in Fig. 2 there was a significant variation in spacing between workstations across those ICT rooms surveyed – this ranged from the lowest value of 150mm to the highest value of 700mm.

![Fig. 2 – Distance between Workstations and compliance with Becta Guidelines](image)
Again, analysis of the ICT rooms in the current study indicated that none of the ICT rooms complied with Becta's recommendations, with the average distance being 502mm between workstations.

However, whilst the rationale for the spacing recommended by Becta was founded upon sound reasoning, changes in both the resources available, as well as teaching and learning practice, have meant that some of the precepts may be open to debate. This is because there has been a significant shift towards flat screen monitors and keyboards in preference to workstations. This coupled with the provision of laptops as both additional and dynamic workstations has a direct bearing on what might comprise an effective workstation.

An ergonomic analysis was, therefore, undertaken to see if a lower threshold for space between workstations was feasible. It was determined that 650 mm would be sustainable in view of current and projected developments in resources and their application. Using this value, an analysis of the ICT rooms surveyed indicates that only 4 of the ICT rooms met or exceeded the recommendation. It was further determined that the minimum effective spacing for workstations could be 600 mm, and in this case some 30% of the current ICT rooms in the second capacity study met this criterion.

c) Environmental Factors (Heat, Light, Ventilation)

The data showed that 36/63 (57%) of classrooms were equipped with air-conditioning and 4/36 (11%) of these worked poorly. 10 (35%) of these classrooms had no windows and 8 relied completely on air conditioning for ventilation. 2 classrooms had both air-conditioning and extractor fans. Of the 41 (65%) of classrooms with windows, 11 (27%) provided poor ventilation. 8 (13%) classrooms had neither air conditioning nor windows. Of these, 6 had fans but in 1 classroom this was ineffective, 1 had an extractor fan that didn’t work and 1 classroom had both fans and an extractor fan.

In conclusion it would appear that many of the classrooms observed in this study were inadequately ventilated. The fact that almost one third of students were working in artificial light is of concern, not just because of the potential for glare but also because of the heat generated by both computers and lights. We know that poor ventilation is likely to affect work performance.

d) Acuity and Sight Lines

As noted previously, a fundamental issue in terms of providing an effective teaching and learning environment is that students can read information that is projected onto screens/interactive whiteboards. There are specific factors, which contribute to this and it is
probably reasonable to suggest that a significant proportion of student engagement within an ICT lesson is derived via Visual Acuity, in terms of students being able to ‘see’ the information that is being projected for them.

In order to analyse the effectiveness of the environment then it is necessary to develop some standardised absolute coordinates, which can be applied to an ICT room.

As has been previously suggested, a key sensory input for students in a modern ICT room is visual, and this will be affected by and impact upon those factors outlined previously (high illumination, target motion, distance-to-target, visual task, target object used).

For this study, it is the 35° eccentricity (Davson, 1990) that is being used as the determinant for the optimum arc of perception acuity. The rationale is that within these parameters, in the attempt to avoid optical imperfections and improve image quality, the fovea becomes exposed to the effects of undersampling and the result is misperception of both stationary (Williams, 1985) and moving (Smith and Cass, 1987), (Thibos and Bradley, 1991) spatial patterns which may also be described as perception degradation.

Using the set Snellen (1855) distance coupled with the Visual Acuity arc, it becomes possible to develop a ‘preferred matrix’ against which an ICT room may be assessed. There will then be a relationship between the length and the breadth of the room, which will in turn enable recommended proportions to be applied. This relationship is known as the aspect ratio as it will derive as a function of the wall containing the ‘Whiteboard’, which will default to being the width of the room. For the purposes of this study, the absolute values of a radius of 6m with an arc of 35° have been applied to the room dimensions of the surveyed rooms, which suggests an aspect ratio of 1:1.6

Only two of the rooms in the study comply with this ratio. In total, <10% are within what might be considered to be acceptable levels based upon the standard values. It is not this simple in terms of analysis, as it is necessary to consider the workspace layout of the rooms, and those that in particular, comply with the ratio. This can be evaluated by ‘layering’ a standard acuity frame into a scaled schematic plan of the ICT rooms. This concept was applied in the development of a “best practice” classroom design (see figs, 3 and 4 below).

2) General Appearance

Of the classrooms observed 6(11%) of classrooms were deemed to be unsatisfactory in appearance. Just under 50% (33) were judged as having very good or good visual appearance. Just under 80% of the classrooms were considered to be “tidy”. (However, we did not provide precise measures for this category and so the results have to be viewed with
caution.) More specifically, data was collected on whether students work, information about assessment criteria, literacy across the curriculum and information about hardware and software were present on the walls. There was an expectation that ICT classrooms should have this kind of information available. Just over half (57%) of classrooms had students’ work present on the walls; even less (49%) had information about assessment criteria and less than one third (29%) had literacy across the curriculum materials. However, 75% of classrooms had information about hardware and software. Taking the overall appearance of the classroom walls a clear picture emerges when all these features are taken into account. There were 5 (6%) classrooms which had none of the preferred features on the wall, 13 (21%) only had 1, 23 (37%) classrooms had 2, 15 (24%) had 3 and only 7 (11%) classrooms were observed that had all of the features on the wall. The data would suggest that more classrooms should contain examples of students’ work and also provide more information about assessment.

3) Equipment

Hardware was, in the main, found to be in good working order. Printing facilities were mostly found to be adequate although more than half of the classrooms did not offer colour printing. Computer control software was also found to be available in a number of schools but was not widely used. In addition, under 50% of the classrooms were judged to be very good/good in visual appearance and generally did not have displays on the wall that conformed to expectations in terms of supporting the learning experience.

4) Management of Resources

This was a small study of the opinions of Network managers and Heads of ICT and it is impossible to draw generalized conclusions from the findings. However, there does seem to be some currency in investigating further the Network manager’s role and their interface with Heads of ICT, technicians and ICT teachers. The best schools had long-term plans developed as a consequence of involving all the different stakeholders. The schools which were poorly equipped tended to have a non-inclusive communication structure.

Some of the suggestions for improving ICT provision included the following:

- More staff training
- Better IT equipment
- More long term planning
- More consultation
- Dedicated IT lessons (not taught through other subjects)
- Better designed rooms
- Improvements in curriculum offerings
Conclusions

The average area of the classrooms visited in this study fell between 50 and 75 m² which was the typical classroom size reported by Becta (2007a). However, 73% were oblong in shape which in the extreme can cause problems with sight lines. The overall design of classrooms was inadequate. The preferred presentation resource within most classrooms was the computer-linked projector and Interactive Whiteboards were prevalent. However, students were often unable to see the projector screens and whiteboards effectively and glare was apparent in many classrooms. Classrooms did not contain workstations away from computers and it was hard to see how group work and discussion could take place. Only 10% of seating had castors and desks tended to be static and of one height. This made any adjustment for the size of child impossible. Occupancy levels in almost every case exceeded Becta and HSE guidelines and issues such as ventilation, acuity and sight lines were inadequately catered for.

Recommendations

1) Classroom Design and Occupancy Levels

Based upon the findings from this study and our review of the literature in the field, initial designs for an ICT classroom have been developed. Using a generous 80m² floor area a number of practicalities have been considered within the design. For example, this layout meets the maximum occupancy level of 18 (Fig. 3) and other constraints (e.g. workstation of 600mm and space between of 650mm), whilst at the same time enables a realistic application of visual acuity for workspace.

Fig 3 – Recommended Design for an 80 m² ICT Classroom
The proposed design (Fig. 3) also takes into account the fact that whilst acuity is based upon a radius of 6m, this does not address the needs of a whole class. This means that the distance of the whiteboard from each pupil needs to be considered. In this way the design will not be in terms of one pupil, but rather in terms of a number of pupils located equidistant from the whiteboard. Thus, for a 160 m\(^2\) classroom two whiteboards/screens/empty wall would need to be located on opposite ends of the classroom to ensure that all students could see the screen easily. (n.b. One projector can produce two images so it is not necessary to install a second projector). (Fig.4)

![Classroom Area: 160 sqm](image)

Fig 4 – Recommended Design for an 160 m\(^2\) ICT Classroom

A further recommendation relates to the provision of workspace away from the computer. The centre space of the classroom needs to be flexible enough that students can either a) sit on one side of a table away from the computer OR b) use tables which allow for the computer to be dropped inside so that students can work on a flat surface in front of them OR C) use laptops. At the very worst, using flat screens should still allow students an opportunity to work together in groups or independently at the side of the screen. We are further recommending
that screens at the side of the room should be angled in such a way that students can easily see the whiteboard or projector screen. For a 160 m$^2$ classroom this could mean that one half of the computer screens are angled at one side of the room and the other half angled towards the opposite end. (see Fig. 4) Either way, flatscreens should afford an opportunity for students to easily access information on the screen as well as having space alongside to do any necessary reading/writing. We do not believe it is essential for teachers to see students screens from either end of the room as the conceptual framework for this classroom sees a teacher moving freely around the room and making use of computer control software when necessary. We would advocate the use of split screen computer control software so that students can see the teacher’s work on one side and can mirror their own work on the other. This is seen as an effective teaching tool especially for learners who need considerable guidance from the teacher.

2) Environmental conditions

Ventilation, lighting and heating are also critical factors in a classroom. One of the most difficult problems to solve is lighting. It is pleasing to note that the University of Sheffield’s Lighting for the Classrooms of the Future project has received funding from the Engineering and Physical Sciences Research Council to undertake a comprehensive study of lighting in classrooms (Fotius & Parnell, 2008). As the researchers have noted, “visual environment, and hence interior lighting, affects a learner's ability to perceive visual stimuli and affects his/her mental attitude, and thus affects performance. Therefore, a review of strategies for classroom lighting is needed to complement proposals for new approaches to teaching and learning.” In the interim, we would recommend that all computer classrooms have a working mechanism to reduce glare (blinds, paper over windows etc.)

Sufficient ventilation also needs to be provided. If windows are not able to be opened then air conditioning should be installed to reduce the incidence of excessive heat during the summer that results in lack of student concentration, teacher exhaustion and computer breakdown. Extractor fans and portable fans can also improve air quality during hot weather. It should never be the case that computer classrooms are constructed so that there are no opening windows or air-conditioning. All classrooms should be equipped with a working thermometer which should be checked regularly. Schools need to appreciate that there are significant costs involved in computers overheating and the subsequent damage that can ensue.

3) General appearance

We recommend that wherever possible a designated teacher should be responsible for the overall maintenance of a computer classroom. We believe that if this does not happen and
the room is used by a large number of teachers in the school, deterioration of equipment and the environment will occur. Classroom displays are also an important feature of a student’s working environment. They should include up to date examples of students’ work, information about hardware and software, assessment criteria and literacy across the curriculum materials.

4) Hardware

Addressing the research on whether laptops in schools represent value for money in comparison with their desktop alternatives is an issue because of budgetary constraints the schools face. There is research to suggest that schools should proceed with caution before they adopt a universal laptop approach (Stevens, 2007). Although tablets and laptops provide considerable flexibility in the delivery of lessons and on the surface would be the preferred option for overcoming the design and capacity issues of classroom design there are problems in relation to their adoption. Research suggests that they are not robust enough to survive continual usage in some secondary school classrooms and that they tend to cost more than the desktop alternative. Lapsaves are a useful option when ICT rooms are unavailable, but again, battery life and screen collapse are an issue as is the general deterioration of the equipment. A cost-benefit analysis needs to be undertaken regarding the use of laptops as well as the ways in which they are financed i.e. leasing versus purchasing. One of the areas that could be explored is whether parents should be involved in the lease/purchase of laptops/tablets equipment and how this would be facilitated.

We believe that access to printers is an essential feature of an ICT classroom. However, the printer needs to be able to handle the capacity in the room. This is not always the case. For ICT classrooms we would recommend at least 2 printers be made available for no other reason than variable demand and pressure on networked systems. We do not recommend that printing be sent to a centralised area requiring students to collect their work outside the classroom.

5) Computer Classroom Furniture.

Although this study did not look in detail at the ergonomic features of classroom furniture, it is clear from visits to classrooms that little attention has been paid to best practice as described in a wide range of available literature. We would advise that a study be undertaken to determine the extent to which schools are addressing the critical issues of ergonomics in new builds and refurbishments as there are significant health and safety issues related to non-compliance. Schools are legally required to provide a safe learning environment. In computer classrooms this would inevitably include issues such as lumbar support and posture, viewing
distance and angle, freedom of movement, adequate space between work stations and lighting. It should also be noted that there is significant literature (e.g. Ergoindemand, 2008, HealthDay News, 2007) to suggest that children are suffering from eye and body strain because of inappropriate furniture and no breaks away from screens, (should be every 20-30 minutes). Clearly these are issues that demand much greater attention in light of the increasing use of ICT in schools.

6) Computer Control Software

Computer Control Software facilitates teachers in controlling the activity of the students as well as enabling them to provide targeted support for every child when they need it. The software also facilitates teachers in sharing the work of specific children amongst the class as a whole. This, in turn, encourages peer review of student work as well as supporting the pupils in taking more responsibility for their learning. It is recommended that all schools install this software and that all teachers and administrators be trained in its use. Once installed this software should be regularly maintained and upgraded.

7) Resource management

Schools should consider developing a tighter model of ownership or supervision of ICT suites to ensure teachers feel supported in their attempts to keep equipment functioning and in place as well as in keeping environments clean and attractive. Additionally a three to four year rolling programme of replacement and improvement of hardware/software needs to be agreed and implemented. A more stable and secure Internet connection needs to be established.

Self- Assessment Tool

As a consequence of the findings from this study a Self-Assessment Tool (SAT) has been developed in order to provide teachers with an objective measure against which they can evaluate the effectiveness of their ICT learning environment. The tool provides an overall evaluation of the classroom environment against researched recommendations and Becta’s guidelines.
Concluding Comments

Overall, our advice would be that all stakeholders need to be consulted in relation to the design of classrooms and the general environment. It is worth noting the comments from the EIS study in Scotland (EIS, 2004). Only 27% of teachers “…felt that their comments during consultation had any impact on the plans for their school….“only 30% believed that their new or refurbished school provides good value for money …Teachers and pupils, janitors and parents, need to be able to participate, not merely ‘be consulted’. In too many cases, it seems, even consultation was limited.” (p. 1) A clear structure for meetings between all stakeholders involved in the delivery of the ICT curriculum needs to be established to facilitate joint decision making in terms of classroom design as well as in purchasing priorities for supporting the teaching of ICT. Such an initiative may then help achieve the government’s vision of building classrooms to meet the changing needs of learning in the 21st century.

N.B. A more detailed account of this study may be found at the Becta Website:  

References


Becta (2007b) How to plan the safe installation of ICT in schools


