EQUITY ISSUES AFFECTING MATHEMATICS LEARNING USING ICT

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Abstract: *Inequities may arise from differential access and use of educational technology in mathematics for groups characterised by gender, ethnicity, income level, and ability. As technology access increases in homes and schools, we ask whether previous inequities are diminished or exacerbated. Equity is considered from the perspectives of opportunities to learn (physical access); educational treatment (how technology is used, by whom); social and psychological factors influencing its use; educational outcomes (achievement, attitudes and motivation). Suggestions for removing boundaries between technology "haves" and "have-nots" are presented.*

Introduction

For several decades, researchers have explored the potential of using technology-based activities to facilitate learning at all levels. It can be argued that since technology has a major impact on teaching and learning - and on employment and everyday life - then all students deserve equal access to its benefits. In this paper we examine research on technology in mathematics education from the perspective of equity. Our concern is with inequities - and consequent barriers to learning - that arise from differential access and use by various groups within the population, particularly those differentiated by gender, ethnicity, social class/income level and ability.

Technology in Schools: Equity Issues in Access and Use

Access to computer and Internet technology. Government initiatives, such as the NGfL scheme in the UK[1], have increased computing technology and Internet availability astronomically since the mid-1980s. A majority of schools in the UK and US now have Internet access - although some offer it only to older or technologically competent pupils (Valentine et al., in press). Despite some successful policies targeted at low-income, minority, and rural schools, the "digital divide" is still

[1] The National Grid for Learning scheme should connect all schools to the Internet by April 2002.

apparent. In an in-depth investigation of inequities in access and use of technology (Dunham & Hennessy, 2001) we reported: gaps between poor and rich nations; ethnic disparities in access; inequitable distribution between schools and regions (relative to SES, minority enrolment, urban and rural schools vs. suburban); greater access to computers in school and at home for boys; more outdated, unreliable hardware or slower Internet connections in poorer schools.

Access to portable technology. Calculator availability in the mathematics classroom has increased steadily with the majority of school students in the UK and US having access to some form of handheld computing technology (Dion et al., 2000). While calculator access seems equitable (re. gender, ethnicity, income), as technology becomes more sophisticated and costly, inequities may increase - especially for access to graphic calculators. Disparities between countries also arise due to differential national policies on access in secondary school classes.

Classroom uses of ICT. Knowing what technology is available in a school does not tell us how often, in what manner, and by whom it is used. Research shows that available technology is often underused and poorly integrated into mathematics curricula.[2] In Britain there is enormous variation between schools and subject departments in take-up of opportunities to use technology (e.g. Hennessy, in preparation). Moreover, differential experiences can create barriers and inequities so that some groups – minority, lower SES, inner-city, rural, disabled, and female students – do not achieve the full potential of educational technology in mathematics education. Finally, while calculator access is generally high, important equity issues arise from the variety of functionalities for different calculators, the effect of course selection on the kind of calculator used, the impact of calculator type on assessment outcomes, and equal access to effective instruction with calculators.

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[2] 98% of the 220 middle schools studied by Huang and Waxman (1996) had computers and calculators available, yet calculators were actually used in mathematics classes only 25% of the time and computers less than 1% of the time.

Ability Issues. The common practice of streaming students by ability in mathematics classes limits opportunities and adversely affects minority and economically disadvantaged students. Its impact on technology use can reinforce inequities. For students in low status classes, computer activities most often involve tutorials and remedial work with drill-and-practice software (Waxman & Padron, 1994). In more affluent schools and higher ability classes, the emphasis is on conceptual development activities such as problem solving and programming. Portable computers effectively support differentiated teaching and may offer more opportunities than desktop machines to tackle the ability differences which interact with equity issues (Hennessy, 1999). For students with learning disabilities, portable use increases student control, self esteem, independence and confidence in using technology (e.g. NCET, 1993).

Social factors and home access. Technology is much more than a physical resource; it is intertwined with social factors which differentially affect interactions. These include family computer cultures, “psychological access”, social identities and exclusion from peer group culture encouragement from others, the setting (alone or with others) for technology use. These issues have a particular relationship with gender identity and are also connected with home access to technology.

A rapid widening in home access is apparent; currently about 70% of British and American homes have computers. However, the distribution of home PCs and of Internet access has become increasingly skewed towards middle-class homes as many families are unable to purchase and constantly update equipment. Boys own and use computers significantly more than girls. Although this division is diminishing, the degree of accessibility within the home disadvantages girls in practice. Race creates inequities in home access too: e.g. African Americans, Hispanics, and Native Americans have lower rates of access and use in the US. Rural communities and certain geographical areas (e.g. the North of Britain) are also at risk from exclusion. In sum, gender, ethnic, and economic differences in physical access to machines at school can be exacerbated by gaps in home access through an interaction between home and school access, whereby privileged children with home access gain greater confidence and familiarity with ICT, tend to dominate school technology, and then experience greater educational advances and achievement (Facer *et al.,* in press).

Differential values placed on specific types of computer expertise within family and peer cultures can influence children’s ICT skills (Facer *et al*., in press; Valentine *et al.*, in press). The Screen Play project confirms the importance of parental guidance and encouragement for young learners. However many parents lack an understanding of the role that digital technology may play in their children’s learning. The degree of integration into family life, prioritisation as a support for children’s learning, hardware and software available, and adult role modelling of computer use vary enormously, posing a subtle source of potential inequity *within* the group of students with home access. The issue of parental support is closely related to both SES and gender. Thus the notion of a digital divide between those who do and do not have home access subsumes some more complex issues than is generally realised.

Gender Differences in Interactions. Male and female students interact differently with technology in terms of physical control, software choices, types of applications, and group settings. Girls voluntarily use computers and the Internet more frequently and confidently at home than at school (Wood, in preparation). Gender role socialisation - linked to technology use within home, school and peer cultures - operates here. Individuals’ attitudes and confidence levels (beyond levels of prior experience) influence their voluntary participation in the use of ICT (“psychological access”: Wood, in preparation). Female exclusion strategies operate even where access appears equivalent; for example, boys tend to dominate school computer clubs, free access sessions, and home equipment.

The private nature of handheld technology mutes the issue of male dominance. The advantages of individual access (confidence, control, independent investigation) may reduce gender differences and explain the benefits of calculator use evident among female students. Collaboration between students – whether sharing machines or not – appears to allay girls' perception that computing is an unsociable activity.

Teachers' Access and Attitudes. Teachers' attitudes toward technology, plus their experience with it and associated pedagogies, affect the extent to which it will be integrated into mathematics curricula. Common constraints perceived by teachers - inadequate software and hardware, not enough time to become familiar with the technology or plan its use, lack of support and inservice training - result in lack of confidence and, in part, explain why teachers tend to use technology only for drill-and-practice (Manoucherhri, 1999).

Teacher attitudes have equity implications for minority, low income and low ability students. Many teachers believe that drill-and-practice activities are more effective for lower-achieving students than for higher-achieving ones because of beliefs about the role of basic skills in mathematics education despite evidence to the contrary.

The impact upon teachers struggling to cope with the home digital divide must not be underestimated. A diverse range of students' prior experience with technology confounds the issue of differentiation while adapting to all pupils' needs (Hennessy, in preparation). Variation in accessibility of ICT between children means that setting homework tasks involving technology further advantages those with home computers; by contrast, some teachers assert the importance of integrating ICT within the curriculum in order to overcome the disadvantages of those without machines at home.

Equity and outcomes of technology use

Differential opportunities to use technology can lead to unequal outcomes in mathematics achievement for skills and concepts, student behaviour in the classroom, and computer competency. In addition, the social and psychological factors underlying inequities related to access and experiences of using educational technology can result in differential attitudes toward mathematics and toward technology.

Student attitudes. The research consistently demonstrates a relationship between computer experience and attitudes toward technology and a circular feedback effect of computer attitudes upon performance. Experience with technology over time can counter negative attitudes, so building up students' experience at home and school may help. The gender effect is very pronounced for attitudes to desktop computing, although not attitudes to portable computers and calculators, which seem to suit girls very well. Despite the advent of more user-friendly technology, the computer culture is more alien to girls (particularly adolescents) who show less confidence, more dislike, disinclination to participate in computer activities, and anxiety than boys.

Mathematics achievement. Research indicates that continual, long-term exposure to computers and calculators is necessary for a positive effect on achievement. Moreover, computer algebra technology has shown promise in developing mathematical concepts without negatively influencing performance of basic manipulations (Dunham, 2000). There is a positive correlation between achievement in mathematics and home access to technology; those without adequate access are denied the innovations that promote increased mathematical understanding.

The equity picture for technology-enhanced achievement is not entirely consistent. Nevertheless, more benefits than deficits are associated with computer and calculator use among groups characterised by ethnicity, SES, and language difficulties. Despite persistent differences favouring boys for computer knowledge and programming achievement, gender-related gaps in mathematics achievement do diminish when students use technology, especially calculators. Frequent participation in a technology-integrated program and access to technology for testing seems to "level the field", alleviating inequities for some traditionally low-performing groups through reduction of computational deficiencies, changes in student behaviour and confidence, and "friendly" pedagogies that promote more equitable instruction and learning. The leveling effect for low-ability and low-confidence students is a strong argument for using technology to achieve equity for disadvantaged groups.

Supportive teaching and learning environments for equity

Merely providing technology does not guarantee that it will be used effectively. To integrate technology successfully and equitably, teachers must deal with content that is structured in new ways and delivered in new formats. They must adapt classroom practice to better accommodate technology use by increasing active and autonomous behaviour, feedback, higher-order thinking, problem solving, and diversity in instructional approaches (Waxman & Padron, 1994). Farrell (1996) reported changes in teacher roles while technology was in use: teachers engaged in more inquiry, with less explaining and more consulting as they monitored student investigations and motivated discussion. These behaviours create more welcoming environments for female and minority students and facilitate greater interest in mathematics. Pedagogies that build on students' cultural experiences and prior knowledge and encourage exploration, conjecturing, reasoning, and decision making often emerge in technology-rich classrooms and can lead to supportive environments that promote equity. Inclusive technology-based activities feature open-ended tasks; teacher as participant, not dictator; cooperative learning in small groups; peer evaluation; emphasis on process rather than outcome; familiarisation and working at the students' own pace;. Meaningful and socially relevant applications, contexts and data are particularly attractive to minority and female students.

Some researchers recommend selecting software and activities carefully for content and style as well as screening for stereotypic images. Minority and female role models - teachers who are competent, confident and enthusiastic technology users - are also important. Parents have a role to play too, in providing children with equipment and support for learning. Software and technology activities also need to build on the diverse experiences of different groups. In sum, if all students are to view technology as a useful resource that plays an increasing role in their lives, then we must avoid further alienating and disadvantaging certain groups.

Conclusions and Policy Recommendations

Any approach to narrowing the digital divide must be multi-pronged, especially as available opportunities to use ICT may not be taken up in practice. Equitable distribution of school resources must be a priority, but funding for equipment alone does not provide the curricular support and on-going professional development - for pedagogical issues, inequity awareness, and the use of technology in developing conceptual understanding - that is crucial. Successful equity interventions may include: compulsory computer classes for all students; monitoring computer use to ensure equal access; establishing policies for software selection and use; training more women and members of minority groups as computer teachers; and direct action to change perceptions about who uses computers (Butler, 2000).

There is a need to explicitly address how ICT is introduced within schools and children's real concerns about exclusion from peer group cultures. Parents and the public need increased awareness of equity issues as much as students and teachers. Increasing out-of-school access for families with limited means is one approach currently being implemented[3]; however, those without computers are least motivated and confident in using them, so schemes to bring technology into disadvantaged communities may have a limited impact. Action to plug the gap must avoid replicating in the classroom external patterns of inequity between students. Specifically, teachers need to employ a wide range of resources and strategies to develop skills and understanding for all students (Downes, 1998). Further suggestions include home-school collaboration, such as schools providing advice in selecting hardware and software and offering technology workshops for parents.

[3] The UK government's 'Computers in Reach' programme leases refurbished computers to poor families and works towards universal Internet access through a network of new IT learning centres in libraries, education and business settings, pubs, football clubs etc.

Finally, *researchers* can help the education community better understand the causes of inequities and can devise and test appropriate instructional strategies and policies for addressing the gaps. Research on the role that technology plays in developing mathematical cognition, the relationship between access and achievement, the effect of the home technology environment, computer practice among different social and ethnic groups, and effective intervention strategies, are all needed. Above all, we need models which acknowledge the complex nature of interactions between learner, family, peer group, teacher, mathematical activity and new technology.

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