2007

Student use of, and engagement with, information technology

John Ainley
Australian Council for Educational Research (ACER), john.ainley@acer.edu.au

Laura Engers
Australian Council for Educational Research (ACER)

MCEETYA ICT in Schools Taskforce

STUDENT USE OF, AND ENGAGEMENT WITH, INFORMATION TECHNOLOGY

John Ainley and Laura Enger
Australian Council for Educational Research

The emergence of Information and Communication Technologies (ICT) has changed the nature of the learning environments experienced by school students (Weiss, 2006). Educators have always created, selected and provided environments for learning and therefore the potential of virtual learning environments is a matter of great interest to them (M. Ainley & Armatas, 2006). Virtual learning environments are seen as having the potential to provide opportunities for active, flexible and individualised learning experiences (Kelleher, 2000: 37). However, M. Ainley and Armatas (2006) argue that the connection between the learner and the learning environment is central to understanding how virtual learning environments motivate or engage students, particularly given the capacity of virtual learning environments to provide more individualised experiences. Indeed, individual differences among learners may be more evident as learning environments become more open-ended (Hartley & Bendixen, 2001).

The research literature on engagement in general has distinguished between three forms of engagement; behavioural, emotional and cognitive (Fredericks et al, 2004). These distinctions provide a means by which students' engagement with information technology can be described. Behavioural engagement refers to participation (both how much and in what forms) in technology-related activities. In this context behavioural engagement pre-supposes opportunities to engage with information technologies. Emotional engagement refers to the ways in which students respond to the use of information technologies and can be considered in terms of their attitudes towards the technologies and their motivation to learn with those technologies. Cognitive engagement refers to the ways in which the interaction with information technology influences approaches to learning, investment of effort in learning and outcomes of learning.

This paper considers the use made of, and engagement with, ICT (mainly in the form of computer technology) by Australian school students. First, it examines students' opportunities to use ICT and their proficiency in various ICT-related tasks. Second, it considers Australian students' behavioural, emotional and cognitive engagement by examining the extent to which and how they use ICT, their interest in and attitudes to using ICT and the ways in which ICT influences their approaches to learning.

Table 1 Computer access at school and home for 15-year-old students in selected countries

Country	Students per computer at school	% students with home computer(a)
United States	3.3	89
Australia	**3.6**	**93**
Korea	3.7	95
United Kingdom	4.3	91
New Zealand	4.3	88
Hong Kong SAR	4.5	93
Canada	4.5	91
Japan	5.3	44
Norway	5.6	94
Finland	5.9	89
OECD Average	6.3	79
Sweden	6.3	95
Netherlands	7.1	96
Italy	7.7	83
Ireland	9.1	80
Greece	12.5	52
Germany	12.5	91
Poland	14.3	61
Indonesia	25.0	8
Turkey	25.0	24
Russia	33.3	29

Note: (a) defined as a computer that can be used for education.
Source: PISA 2003school questionnaire; PISA 2003 student questionnaire

Opportunities for using ICT

Australian students have substantial opportunities to engage with computers and information technologies at home and school. Data in Table 1, taken from the OECD Programme for International Student Assessment (PISA) conducted in 2003, indicate that Australia has one of the highest levels of computer availability in secondary schools among OECD countries, with an average of 3.3 students per computer (OECD, 2005). These findings also highlight an improvement in school provision of computing resources in Australia over the three years since the PISA 2000 survey, where an average of 4.5 students per available computer was found.

Data from PISA 2003 also provide information about the extent to which 15-year-old students have access to computers at home (OECD, 2005)[1]. As can be seen in Table 1, 93% of Australian students indicated that they had a computer at home which they could use for school work. Findings from PISA 2003 also revealed that, of participating Australian students,:

- 96% indicated that there was a computer of some type at home;
- 83% had a link to the internet; and
- 67% had educational software for the computer.

In Australia there was only a small (non-significant) difference in computer access between metropolitan and non-metropolitan schools (3.4 compared to 3.8 students per computer respectively). Evidence from the PISA surveys, shown in Table 2, indicates the extent of unequal access to home computing resources by socioeconomic background.

For Australia the magnitude of the "digital divide" is less than in other OECD countries and is mainly between students in the lowest quarter of the socioeconomic distribution and other students.

Table 2 Home computer access by socioeconomic background for 15-year-old students

	% students with access by SES Quarter			
	Lowest	Lower	Higher	Highest
Australia				
Any computer	89	98	99	100
School work computer	82	97	98	100
OECD				
Any computer	67	83	92	97
School work computer	58	77	87	94

Source: OECD (2005)

The PISA 2003 study only provides information regarding the opportunity for secondary school students to access computers. However, findings from the Trends in International Mathematics and Science Study (TIMSS) suggest that primary school students enjoy a similar level of access (Thomson & Fleming, 2004; Martin et al., 2004) (see Table 3). From those data in Table 3 it can be seen that Australian Year 4 students have high levels of access to computing at school and at home.

Table 3 Computer access at home for Year 4 students in selected countries (TIMSS 2002/3)

Country	% with a computer at home	% using at home & school	% using at school not home	% using at home not school
Australia	**92**	**81**	**12**	**7**
Belgium	90	66	6	21
England	91	79	11	8
Hungary	71	24	9	43
Italy	79	30	12	38
Latvia	42	10	17	27
Netherlands	93	79	4	12
Norway	91	60	5	28
Singapore	89	71	8	17
Hong Kong SAR	85	76	11	9
Japan	77	54	31	9
New Zealand	87	71	13	12
Scotland	89	78	12	8
United States	92	73	11	12
Canada - Ontario	92	78	7	12
Canada - Quebec	89	75	10	12

Source: Mullis et al (2004).

[1] In Australia PISA 2003 involved 321 schools and just over 12 500 students participated in PISA (Thomson, Cresswell & de Bortoli, 2004). PISA data refer only to secondary schools in the Australian school structures

The findings indicate that the majority of Year 4 students in Australia have access to a computer at home and that most students use a computer both at home and at school. Further, the percentage of Australian students indicating that they have a computer at home is comparable to the percentage of students reporting home computer access in the United States, England and the Netherlands.

Proficiency in using ICT

Since being able to make use of information technology for learning presupposes competence in performing computer tasks, a key consideration when examining the relationship between engagement and ICT must be a consideration of students' self-rated competence in relation to those tasks. PISA 2003 provides information about student self-reports of their competence in information technology.

Table 4 Percentages of 15-year-old students who could perform various ICT tasks by themselves.

	OECD average	Australia
Routine tasks		
Save a document or file	88	97
Print a document or file	86	97
Open a file	90	96
Scroll a document	87	96
Delete a document or file	88	96
Play computer games	65	93
Create/edit a document	80	92
Start a computer game	86	91
Copy a file from floppy disk	75	89
Move files on a computer	76	89
Draw pictures using a mouse	85	89
Internet tasks		
Get on to the internet	88	97
Write and read emails	79	92
Copy or download files from internet	70	86
Download music from internet	66	79
Attach a file to an email message	58	76
Higher level tasks		
Create a presentation	47	77
Use database to produce addresses	32	68
Use a spreadsheet to plot a graph	44	58
Create a multimedia presentation	35	48
Find and get rid of computer viruses	37	44
Construct a web page	28	37
Create a computer program	21	27

Source: OECD (2005)

Table 4 indicates the percentage of 15-year-old students who were confident they could perform various computing tasks by themselves. Those data indicate that a large majority (nine in ten or more) of Australian 15-year-old students are confident about their capacity to perform routine computer tasks. Further, a substantial majority are confident of their ability to perform various internet tasks (more than three in four) but somewhat fewer are confident of being able to perform higher level tasks. The data in Table 4 also indicate that a higher percentage of Australian 15-year old students are confident in their capacity to perform these tasks than is the case on average across the OECD.

Table 5 provides information based on three indices of confidence in performing routine, internet and high-level computer tasks[2]. Those data indicate that Australian 15-year-old students are more confident of their ability to perform these computer tasks than their peers in most other OECD countries. This level of confidence may reflect extensive experience with computer technology. The findings of PISA 2003 indicated that the majority of Australian 15-year-old students have at least three years of experience using a computer.

Values of the index can also be used to compare the computer confidence of various sub-groups in relation to each group of tasks (OECD, 2005).

Those comparisons indicate that within Australia:

- 15-year-old males are more confident than 15-year-old females of their capacity to perform these ICT tasks;
- the difference between male and female confidence is greatest on high level ICT tasks (0.46 standard deviations), less on internet tasks

[2] The indices were constructed in a similar way to those computed for attitudes. They provide a relative indication of confidence in that each index is standardised on the OECD average within each set of tasks. A high score indicates greater confidence and two-thirds of scores are bounded by the values of -1 and +1. Consequently, a difference in values of the index can be taken as a fraction of a standard deviation. In Table 8 the decimal point has been dropped for clarity.

(0.17 standard deviations) and least on routine tasks (0.13 standard deviations); and

- the difference between male and female student confidence to perform these ICT tasks is smaller than for the OECD average (but larger than for the United States).

Table 5 Index values for confidence in performing computer tasks among 15-year-old students (PISA 2003)

Country	Index of confidence in relation to ICT tasks		
	Routine	Internet	High-level
Australia	**39**	**41**	**42**
Belgium	11	23	04
Canada	33	57	35
Denmark	15	11	06
Finland	08	06	04
Germany	15	13	08
Greece	-38	-45	-22
Ireland	-03	-37	24
Italy	-20	-39	-15
Japan	-80	-71	-71
Korea	08	77	-09
New Zealand	20	31	22
Sweden	21	39	00
United Kingdom	25	28	31
United States	26	39	43
OECD Average	00	00	00

Source: OECD (2005)

To illustrate the difference between males and females in confidence regarding high-level ICT tasks the differences across the specified tasks are shown in Table 6. The biggest differences related to being able to 'find and get rid of computer viruses' and 'creating a computer program', with males indicating greater confidence. There were modest differences in 'creating a presentation', 'creating a multimedia presentation' and 'constructing a web page'. There were only small differences in 'using a spreadsheet to plot a graph' and 'using a database to produce addresses'.

Table 6 Percentages of Australian 15-year-old students who could perform various ICT tasks by themselves or with help

	% of students	
	Males	Females
Create a presentation (PowerPoint)	88	79
Use database to produce addresses	92	89
Use a spreadsheet to plot a graph	89	84
Create a multimedia presentation	88	79
Find and get rid of computer viruses	84	64
Construct a web page	80	71
Create a computer program	70	52

Note: These data differ from those in Table 7 in that they incorporate students who were confident of performing the task either by themselves or with help.

Source: OECD (2005)

Behavioural Engagement

Using ICT

According to data from PISA 2003, 90% of 15-year-old students in Australia responded that they had used a computer for more than three years and 69% that they had used a computer for more than five years. More than half (55%) of the students indicated that they used a computer at home almost every day (and a further 32% that they used a computer at home a few times each week).

Table 7 Percentage of 15-year-old students using computers at least a few times each week

Country	% at school	% at home
Canada	40	90
Sweden	48	89
Australia	**59**	**87**
Korea	28	86
United States	43	83
Germany	23	82
United Kingdom	71	81
Finland	36	78
Italy	51	76
OECD Average	44	74
Ireland	24	61
Japan	26	37

Source: OECD (2005)

As shown in Table 7, 59% of 15-year-old students used a computer at least a few times each week at school and 87% used a computer at least a few times each week at home. Australia records the second highest level of computer use at school, after the United Kingdom.

The percentages of 15-year-old Australian students who used various functions of a computer at least "a few times each week"[3] are shown in Table 8. The table distinguishes between those activities primarily relating to the internet and entertainment and those activities relating to software applications. Overall, a higher percentage of students used computers on a weekly basis for accessing the internet or for entertainment purposes than for accessing software applications. Of the listed activities in this category, 'looking up information' and 'communication' had the highest percentage of males and females reporting usage on at least a weekly basis. A smaller percentage of students reported at least weekly use of various software programs and applications; only the use of word processing programs was reported by a high percentage of students. A relatively low percentage of students indicated that they use mathematics programs, spreadsheets or programming applications on at least a weekly basis.

For most of the computer functions listed, a higher percentage of males reported engaging in the activity on at least a weekly basis than females. There were several activities for which the difference between males and females was particularly pronounced. For example, the percentage of males indicating that they use computer games on at least a weekly basis was double the percentage of females who reported doing so. In addition, a higher percentage of males reported that they download software, access educational software and use computers for programming on at least a weekly basis than females. On the other hand, a higher percentage of females indicated that they use word processing programs on at least a weekly basis than males.

3 These estimates combine the percentages for those who said that they used the application "almost every day" with those who said that they used it "a few times each week".

Table 8 Percentages of 15-year-old Australian students using computer functions at least a few times each week.

Function	% using at least weekly		
	Males	Females	Total
<u>Internet & entertainment</u>			
Look up information	76	72	74
Communication (email & chat)	68	69	69
Download music	62	53	58
Computer games	67	33	50
Download software	58	35	47
Collaborate with a group	46	40	43
<u>Programs & applications</u>			
Word processing	67	73	70
Drawing or graphics programs	38	27	32
Learn school material	34	30	32
Programming	32	17	25
Spreadsheets	25	20	22
Educational software (eg maths)	13	8	10

Source: PISA 2003 student questionnaire
Note: All differences are statistically significant except for communications

It is interesting to consider the potential reasons for these discrepancies. Do they arise from different subject choices, and therefore different homework requirements, for males and females? Or do they reflect broader differences in the leisure pursuits of male and female students or differences in the purpose for which they use computers?

Differences between males and females in their use of computer technology have been the focus of a number of studies. Research has generally provided support for the contention that computer games are more avidly consumed by boys than girls but that girls are more likely to use computer technology for communication (Colley & Comber, 2003; Griffths, Davies & Chappell, 2004; Subrahmanyam et al, 2002). The issue of whether there are gender differences in the use of other forms of information technology remains unresolved. While the PISA 2003 study revealed some differences in the types of computer programs and applications frequently used by male and female students, other studies have suggested that there is no difference between males and females in their use of various software programs or in their use of programming applications (Colley & Comber, 2003). There is some evidence to suggest that the gender gap in computer usage has decreased over time and that there has been a reduction in the disparity between male and female attitudes to computers (Colley & Comber, 2003; Whitley, 1997).

Regardless of the gender differences noted in the PISA 2003 study, it seems clear that 15-year-old Australian students are frequently using computers for the purposes of communication. This is consistent with what has been found in other, less formally structured surveys conducted in the United States and Canada. NetDay (2004) found that 54% of students in Years 6 to 12 in the United States answered 'yes' to the question 'do you know more of your friends' instant message (IM) screen names than their home phone numbers?' A Canadian survey of 12 to 17 year olds found that the majority of internet use was for the purpose of activities related to socialising (e.g., e-mailing and using instant messaging). This suggests that internet technology is a major form of communication for secondary students in both the United States and Canada.

Levin and Arafeh (2002) conducted interviews with American teenagers and found that the internet was used for a wide range of education-related purposes, from research, to corresponding with teachers and classmates about school projects. This suggests, consistent with the PISA 2003 data, that information technology is used by students for a broad range of purposes – both educational and otherwise.

Emotional Engagement

Attitudes and Interests

The attitudes of students to the place of computers in education and in their lives are crucial to understanding the motivation of students in virtual learning environments. The most common medium for accessing information technology is the personal computer. In general it appears that students are favourably disposed towards working with computers. Four questions in the PISA 2003 student questionnaire asked students about their experience of working with computers[4].

Table 9 records the scores on an index of student attitudes towards computers from a number of countries[5].

Table 9 Index values for attitudes to computers among 15-year-old students (PISA 2003)

Function	Index of attitudes to computers		
	Total	Females	Males
Korea	25	11	34
Germany	25	-03	54
Canada	15	03	28
Belgium	13	-07	31
Greece	08	-09	26
United States	07	02	12
United Kingdom	07	-09	23
OECD Average	00	-19	19
Italy	-07	-24	11
Australia	**-10**	**-26**	**07**
New Zealand	-10	-23	02
Sweden	-10	-39	20
Denmark	-24	-67	19
Ireland	-32	-39	-26
Finland	-38	-63	-12
Japan	-41	-41	-42

Source: PISA 2003 student questionnaire

Australian students had slightly less positive attitudes to computers than the average for OECD countries but similar to their counterparts from New Zealand and Sweden.

In all countries males had more favourable attitudes to computers than females except in Japan where the difference was not significant. However, the magnitude of the difference varied widely among countries from the United States (where the difference was small) to Denmark (where the difference was large). The difference between male and female

[4] Abbreviated forms of four statements were: "it is important to me to work with a computer"; "working with a computer is fun"; "use a computer because very interested" and "lose track of time when working with a computer".

[5] The index was constructed so that it combined responses on the four questions so that the average across all OECD countries was zero and two thirds of the student scores fell between -1 and +1. Consequently, a difference in values of the index can be taken as a fraction of a standard deviation. In Table 6 the decimal point has been dropped for clarity.

attitudes in Australia was about the same as for the OECD average.

An analysis reported as part of PISA indicates some of the factors associated with positive attitudes to computers (OECD, 2005). For Australia the factors associated with positive attitudes to computers are: gender (males have more positive attitudes), whether the student taught themselves to use a computer, the frequency of computer use and having a computer at home. However, a considerable amount of the variance in attitudes to computers remains unexplained by these factors.

The index provides a good indication of the relative strength of attitudes to computers between countries and between groups of students within countries. An absolute sense of student attitudes can be gleaned from the percentages of Australian students who strongly agreed with the four statements.

- important to me to work with a computer (45%)
- working with a computer is fun (43%)
- use a computer because very interested (35%)
- lose track of time when working with a computer (34%)

These items indicate a sequence from the most favourably rated aspect to the less favourably rated aspect. The fourth of the items invokes the concept of "flow" (Csikszentmihalyi, 1990). "Flow" represents an intense and absorbing experience of engagement with a task or a heightened level of motivation. Flow has been used as a central construct in investigations of learning in a range of virtual environments (Chen, Wigand & Nilan, 1999). Although much of the research on flow has focussed on students in higher education the concept has been identified in the way senior secondary school students interact with a computer-based writing task (M. Ainley, Enger & Kennedy). The PISA 2003 findings suggest that, for many students, interacting with computers is an absorbing and interesting experience.

However, technology in and of itself is unlikely to be the direct source of students' engagement. According to flow theory, an optimal learning experience will occur when an individual's skills are sufficiently challenged by a task (Csikszentmihalyi, 1990). In the case of ICT, the challenge may stem from the need to navigate and assimilate a wide range of complex information and from the opportunity to interact directly with the material, rather than from the features of the technology itself. M. Ainley and Armatas (2006) highlight the potential of virtual learning environments to transcend the limitations of time and space in their offerings to students. The extent to which students engage with a virtual learning environment may depend on the quality of the instructional message (Mayer, 1997), the interaction with the learner (Mayer & Chandler, 2001), and the design and interactivity of the instructional material (Salzman, Dede, Loftin & Chen, 1999).

Oblinger (2004) and Gee (2003) both argue that games and simulations are potentially powerful learning environments because of the extent to which they engage participants, the interactive nature of involvement and the wide range of resources that can be utilised. De Castell and Jensen (2006) indicate that educational games or simulations operate by engaging the attention of learners and then holding the attention of those learners. They suggest that there may be a number of benefits associated with the application of gaming technology to virtual learning environments (de Castell & Jensen, 2006). Among these are the chance for students to proceed at their own pace through structured learning tasks and the opportunity for students to become immersed in a task (in a condition similar to that of flow). Vogel, Greenwood-Ericksen, Cannon-Bowers and Bowers (2006) argue that the use of games (both those including simulations and those without simulations) influences learning through enhanced motivation and by increasing learner control and feedback. Sohn (2004) argues that greater recognition is needed of the potential for the new technologies used in computer games to improve attention, inspire new interests and, as a result, improve learning.

ICT and Student Learning

An important cognitive aspect of student engagement with Information and Communication Technology (ICT) is whether and how the use of ICT impacts on approaches to learning.

One argument concerning the influence of ICT on approaches to learning is that differences in approaches to learning arise from differences in prior experiences. It is argued that those who grew up with digital technologies adopt different approaches than those who did not (Jukes, 2005; Prensky, 2004; Tapscott, 2004). Students who have been exposed to digital technologies approach technology with the expectation that it will provide a high level of engagement and that it will enable them to pursue an interest through access to a wide range of resources. Strategies for adapting teaching to better meet these students' needs and expectations include increasing the speed at which information is presented, providing opportunities for multi-tasking and interactive learning, and presenting information through a variety of media (Jukes, 2005).

Another argument is that students learn to use different approaches to learning through their access to ICT. This is evident when groups of students worked together as communities of learners to build shared knowledge. One of the best known examples of this is the Knowledge Forum[6] which is based on a conferencing system and database operated through networked computer software (Scardamalia & Berieter, 1994). The Knowledge Forum provides a structure that nurtures the development of inquiry and collaboration skills to provide a better basis for sharing and developing knowledge. Studies of student learning in such communities suggest that they assist students to gain skills in knowledge building processes (Goldman et al, 2003).

A third argument is that ICT facilitates learning through trial and reflection by enabling access to a richer range of learning resources. Banks, Cresswell and Ainley (2003), from an analysis of PISA 2000 data, suggest that greater familiarity and ability with computers facilitates the adoption of strategies that allow for a more extended pursuit of possibilities and, ultimately, provides the individual with more control over their own learning.

Analyses that have investigated the connections between student use of ICT and performance on cognitive assessments have reported mixed results. From a large-scale study in Iowa, Ravitz, Mergendoller and Rush (2002) reported a positive association between student achievement and computer proficiency and home computer use. That is, students with higher levels of computer use and proficiency with computers tended to have higher levels of achievement (Ravitz et al., 2002). On a much smaller scale in the United Kingdom, Valentine et al (2005) also report a positive association between using computers at home and performance on mathematics tests. However, it is hard to incorporate adequate controls for other factors that might influence both computer use at home and test performance (Wenglinksy, 1998; Roschelle et al, 2002). The OECD (2005) reported on an analysis of data from PISA 2003 and suggested that there was an association of computer use at home and confidence in the use of computers with mathematics performance. However, some of the relationships were non-linear, with moderate use being associated with better performance than the highest levels of computers use. It is not possible in these analyses to be sure whether the home computer use and confidence in computer ability are reflections of other abilities that also influence mathematics test performance.

Research on engagement with ICT

In the ever growing body of research literature on ICT and learning it seems that the ways in which, and the extent to which, students engage with learning tasks is crucial. In general the evidence suggests that the use of ICT enables richer, more engaging learning environments to be developed. However, it is also evident that the use of ICT does not always result in greater emotional engagement or stronger cognitive engagement with learning. There is too much variation among learners and the nature of learning tasks to expect conclusions that can be applied uniformly regardless of context.

[6] Formerly known as CSILE.

Winn (2002) suggests that research on educational technology has evolved through four stages. Initially there was a focus on the relationship between content and instructional design. Then there was a wider consideration of how format and student characteristics interact, followed by an interest in studying how students could use technology to regulate their own learning. Now there is an interest in using modern media technologies to generate more interactive learning environments through which students can access material from more diverse sources and share deliberations with other learners. An important step in this research will be determining which features of virtual learning environments are most conducive to learning and how these environments can be shaped to suit the needs of the individual.

The study of the impact of learning environments on student engagement has a long history. The emergence of computer-based and virtual learning environments raises new challenges and the prospect of using the tools of information technology to investigate student learning.

References

Ainley, M. & Armatas, C (2006). Motivational perspectives on students' responses to learning in virtual learning environments. In Weiss, J. Nolan, J. Hunsinger, J and Trifonas, P. (Eds.). *The International Handbook of Virtual learning Environments.* Dordecht, the Netherlands, Springer, 365-394.

Ainley, M., Enger, L., & Kennedy, G. (Accepted for publication). The elusive experience of flow: Qualitative and quantitative indicators. *International Journal of Educational Research*.

Banks, D., Cresswell, J., & Ainley, J. (2003). Higher order learning and the use of ICT amongst Australian 15 year olds. Paper presented at the International Congress of School Effectiveness and Improvement, Sydney, January.

Chen, H., Wigand, R., & Nilan, M. (1999). *Computers in Human Behavior* 15, 281-296.

Colley, A., & Comber, C. (2003). Age and gender differences in computer use and attitudes among secondary school students: What has changed? *Educational Research, 45* (2), 155-165.

Csikszentmihalyi, C. (1990). *Flow: The Psychology of Optimal Experience*. New York: Harper & Rowe.

De Castell, S. & Jensen, J. (2006). Education gaming and serious play. In Weiss, J. Nolan, J. Hunsinger, J and Trifonas, P. (Eds.). *The International Handbook of Virtual learning Environments.* Dordecht, the Netherlands, Springer, 999-1018.

Fredericks, J., Blumenfeld, P., & Paris, A. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research* 74(1), 59-96.

Gee, J. (2003). *What Video Games Have to Teach us about Learning and Literacy.* New York: Palgrave McMillan Press

Goldman, S., Duschl, R., Ellenbogen, K., Williams, S., & Tzou, C (2003). Science inquiry in a digital world: possibilities for making thinking visible. In van Oostendorp, H. (ed.) Cognition in a digital world. Mahwah, NJ: Lawrence Erlbaum and Associates, 253-283.

Griffiths, M.D., Davies, M.N.O., & Chappell, D. (2004). Demographic factors and playing variables in online computer gaming. *CyberPsychology and Behavior, 7* (4), 479-487.

Hartley, K. & Nendixon, L. (2001). Educational research in the internet age: examining the role of individual characteristics. *Educational Researcher* 30(9), 22-26.

Jukes, I. (2005, May). *Understanding Digital Kids (DKs): Teaching & learning in the new digital landscape.* Retrieved May 25, 2005, from http://www.thecommittedsardine.net/infosavvy/education/handouts/it.pdf

Kelleher, R. (2006). A review of recent developments in information and communication technologies (ICT) in science classrooms. *Australian Science Teachers Journal* 46 (1), 33-38.

Levin, D., & Arafeh, S. (2002, August 14). *The digital disconnect: The widening gap between Internet-savvy students and their schools.* Retrieved May 25, 2005, from http://www.pewinternet.org/report_display.asp?r=67

Martin, M., Mullis, I., Gonzalez, E., & Chrostowski, S. (2004). *TIMSS 2003 International science Report: Findings from IEA's Trends in International Mathematics and Science Study at the Fourth and Eighth Grades*. Boston: International association for the Evaluation of Educational Achievement.

Mayer, R. & Chandler, P. (2001). When learning is just a click away: does simple user interaction foster deeper understanding of multimedia messages? *Journal of Educational Psychology* 93 (2), 390-397.

Mayer, R. (1997). Multimedia learning: Are we asking the right questions? *Educational Psychologist* 32 (1), 1-19.

Mullis, I.V.S., Martin, M.O., Gonzalez, E.J., & Chrostowski, S.J. (2004). *Findings from IEA's Trends in International Mathematics and Science Study at the Fourth and Eighth Grades*. Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Boston College.

NetDay. (2004, March). *Voices and views of today's tech-savvy students: National report on NetDay Speak Up Day for Students 2003.* Retrieved May 25, 2005, from http://www.netday.org/downloads/VOICES%20AND%20VIEWS%20final.pdf

Oblinger, D. (2004). The next generation of educational engagement. *Journal of Interactive Media in Education* 8, 1-18.

Organisation for Cooperation and Development (OECD) (2005). *Are students ready for a technology-rich world: What PISA studies tell us*. Paris: OECD.

Prensky, M. (2004). *The emerging online life of the digital native: What they do differently because of technology, and how they do it.* Retrieved May 25, 2005, http://www.marcprensky.com/writing/default.asp

Ravitz, D. Mergendoller, J., & Rush, W. (2002). What's school got to do with it? Cautionary tales about correlations between student computer use and academic achievement. Paper presented to the annual meeting of the American Educational Research Association, New Orleans, April.

Roschelle, J. M., Pea, R. D., Hoadley, C. M., Gordin, D. N., & Means, B. M. (2002). Changing how and what children learn in school with computer-based technologies. [Electronic Version]. *The Future of Children: Children and Computer Technology, 10 (2),* 76-101. Retrieved May 25, 2005, http://www.futureofchildren.org

Salzman, M., Dede, C., Loftin, R, & Chen, J. (2002). A model for understanding how virtual reality aids complex conceptual learning. *Presence: Teleoperators and Virtual Environments* 8 (3), 293-316.

Scardamalia, M. & Berieter, C. (1994). Computer support for knowledge-building communities. *Journal of Learning Sciences* 3 (3), 265-283.

Sohn, E. (2004) What video games can teach us. *Science News for Kids*, Jan 21, 2004. Retrieved May 25, 2005, from http://www.sciencenewsforkids.org/articles/20040121/Feature1.asp

Subrahmanyam, K, Greenfield, P., Kraut, R., & Gross, E. (2002). The impact of computer use on children's and adolescent's development. In Calvert, S., Jordan, A., and Cocking, R. (Eds.). *Children in the Digital Age: Influences of Electronic Media on Development*. Westport CT: Praeger.

The Internet Is Changing The Way In Which Teens Socialize In Canada. Retrieved 25 May 2005 http://www.ipsos-na.com/news/pressrelease.cfm?id=2476

Tapscott, D. (1997). *Growing Up Digital: The Rise of the Net Generation*. Retrieved 25 May 2005: http://mbhs.bergtraum.k12.ny.us/cybereng/ebooks/growdigi.htm

Thomson, S. & Fleming, N. (2004). *Examining the Evidence: Science Achievement in Australian Schools in TIMSS 2002*. Melbourne: ACER.

Thomson, S., Cresswell, J. & de Bortoli, L. (2004). *Facing the Future: PISA 2003 in Australia*. Melbourne: ACER.

Valentine, G., Marsh, J., & Pattie, C. (2005). *Children and Young People's Home Use of ICT for Educational Purposes*. London: DFES.

Vogel, J., Greenwood-Ericksen, A., Cannon-Bowers, J., & Bowers, C. (2006). Using virtual reality with and without gaming attributes for academic achievement. *Journal of Research on Technology in Education*, 39 (1),105-118.

Weiss, J. (2006). Introduction: Virtual learning and learning virtually. In Weiss, J., Nolan, J., Hunsinger, J., & Trifonas, P. (Eds.) *The International Handbook of Virtual learning Environments*. Dordecht, the Netherlands, Springer.

Wenglinsky, H. (1998). *Does it Compute? The Relationship between Educational Technology and Student Achievement in Mathematics.* Princeton, NJ: Educational Testing Service Policy Information Centre.

Whitley, B.E. Jr. (1997). Gender differences in computer-related attitudes and behaviour: A meta-analysis. *Computers in Human Behavior, 13* (1), 1-22.

Winn, W. (2002). Current trends in educational technology research. *Educational Psychology Review* 14(3), 331-351.

Prepared for the ICT in Schools Taskforce by the Australian Council for Educational Research