An Ergonomic Questionnaire Survey on the Use of Computers in Schools

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Abstract: A questionnaire was sent out to elementary, junior high and high schools in Yokohama and Kawasaki Cities from January to March 1998 regarding the use of personal computers by pupils and students. The survey included the questions that asked how often and in what environment computers are used, whether any instructions are given as to their use, children's working posture, and the effect on health. The results show that most schools are slow to develop instructive programs from the environmental or ergonomic point of view. So far there are not many children who complain of any serious symptoms such as pain in the neck, head or shoulders, but a future increase in the number of classes which involve computing, as well as the widespread popularity of home computers, will surely arouse a legitimate concern about the health of pupils and students, since they will spend more and more time operating the devices. An effective way to anticipate the problem is to provide young students with adequate knowledge of easy-on-body usage and environmental design, and now there is an urgent need for specific guidelines to protect them.

Key words: VDT work, Computer, Ergonomic Education, Student, Effects on Health, Questionnaire

Introduction

Since the early 1990s many countries have included computer education in their school curricula. Japan has the reformed National Curriculum Standards published from 1998 to 1999, which require that junior high school students learn information-related matters as part of their Industrial Arts and Homemaking course from 2002, and a new obligatory course of Information Study be established in high schools from 2003. While no special subject is set for elementary school children under these reformed National Curriculum Standards, consideration is called for to "enrich their educational activities to help them become familiar with, and properly use, computers, information-communication networks and other information media". In compliance with these official requirements, each school is now acquiring computer devices and rapidly paving the way for curriculum reorganization.

Personal computers had been introduced into workspaces early in the 1970s, prior to use in schools. Displays and keyboards, whose optical and physical characteristics are totally different from those of paper and pencil, caused a sharp increase in the number of users experiencing eye fatigue, pain or dryness, shoulder stiffness, and back and low back pain. Among the many subsequent surveys and experimental studies, Saito observed that when working at a computer one's posture tends to become more tightly restrained and eye movement busier than when writing with "pencil and paper"¹⁾, Sotoyama noted that the ocular surface area, the surface area of the eyeball which exposed to the air, increases due to upward gaze²⁾, and Abe pointed out a decrease in tears during upward gaze³⁾ all referred to as among causative factors in shoulder stiffness or eye pains.

Based on these findings, suggestions have been made as to device requirements, how to use computers with less strain on the body and how to design an ergonomically good computer environment⁴⁻⁸⁾.

The adoption of computers in schools is proceeding apace

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now, but is the accumulated know-how utilized in any effective way? If such rapid adoption continues without due consideration of users, there is a chance that some pupils and students will suffer from physical disorders, just as adults did on the computerization of office work.

We saw the need for recognizing the current state of the computer environment and usage, and this constituted the motivation for the said questionnaire survey which included the ergonomic viewpoint.

Methods

The subjects were 100 elementary schools, 50 junior high schools and 50 high schools, selected randomly from among the elementary, junior and high schools in Yokohama and Kawasaki Cities, including both public and private. Copies of the questionnaire entitled "A Questionnaire on Computers and Their Use in Schools" were sent out to be received by the teachers who were engaged in computer education but not expert in computer handling. Two copies were sent to each elementary school, one for the lower graders (1–3) and one for the higher graders (4–6). Each junior high and high school received one copy. The term of the survey was from January to March 1998.

Results

The response rate was 75% for elementary, 80% for junior high and 68% for high schools.

Questions 1 to 3 in the tables show the results which include all the schools that responded the questionnaire, and Q4 to Q23 include only those schools which had already introduced computers into their curricula. In the latter case, the number of schools already using computers is counted as 100%, each reported percentage being the ratio of the number of schools whose answers fell into the corresponding group to the number of schools already using computers.

1. Questions concerning computer education and its contents (Q1–Q5)

The results are shown in Table 1.

Q1: The average numbers of students per school in elementary, junior high and high schools are around 500, 550 and 900, respectively.

Q2, Q3: As of March 1998, the schools that had adopted computers constituted 40% of the elementary, 90% of junior high schools and 70% of high schools. About 10% of the junior high and high schools answered that they are "making positive efforts in computer education". Relatively higher-

grade classes had adopted computers earlier than lower-grade classes in the same school.

Q4: The main teaching focus was on graphics for elementary lower-grades pupils, word-processing and graphics for both elementary higher-grades and junior high students, and programming and word-processing for high school students. About 20% in each category had introduced Internet education.

Q5: Only several percent in each category of schools answered that they were actively teaching the students in an appropriate environment that they should use a computer. About 30% of the elementary and high schools, and about 60% of junior high schools answered that they were doing that "within a limited scope". Those which were "not at all" making such efforts exceeded 60% in both elementary and high schools.

2. Questions concerning how computers are used (Q6–Q10)

The results are shown in Table 2.

Q6: Among those schools which had computer-related curricula, about 40% of the elementary and more than 90% of the junior high and high schools had special rooms for computers. Although a total of 50% were provided with an Internet-accessible machine environment, comparison with Q4 shows that not all of them were utilizing it in Internet education.

Q7: The number of computers installed was nearly one for every 10 to 20 pupils or students.

Q8: The higher the grade, the higher the percentage of schools in whose computer classes at least one computer was available for each pupil or student. In almost 100% of the elementary schools one computer was shared by more than 2 users at a time, and it was 2 to 3 users per computer in more than 90% of junior high schools; whereas in contrast, nearly 70% of high schools made it possible for each student to use a machine for him or herself.

Q9: The higher the grade, the longer the hours per week a pupil or student worked at a computer. In 90% of the elementary and junior high schools the use of a computer did not exceed 2 hours per week, whereas in about 30% of the high schools it did exceed 2 hours.

Q10: Pupils and students were not permitted the free use of computers during breaks or after hours, except in less than 40% of each school category.

3. Questions concerning computer equipment (Q11–Q14)

The results are shown in Table 3.

Q11–13: While desktop machines were mainly used in more than 90% of each junior high and high school, the portable

Table 1. Questions concerning computer education and its content

Q1. How many students are there in your school?		Q2. Are you carrying out computer education - for example on how to use the INTERNET?			
	Number of students		None	Limited	Extensive (%)
Low grade	243	Low grade	72	25	3
High grade	263	High grade	55	43	3
Junior high	553	Junior high	13	78	10
High school	885	High school	32	53	15

Q3. Are computers used as tools in the teaching of other subjects?				
	None	Limited	Extensive	(%)
Low grade	75	21	4	
High grade	59	35	5	
Junior high	30	68	3	
High school	38	59	3	

Q4. If the answer to question 2 is "limited" or "extensive", is computer education given concerning?					
	Programming	Word processing	Image/picture handling	Internet	Other (%)
Low grade	0	41	82	14	32
High grade	3	83	86	26	43
Junior high	25	81	81	14	14
High school	44	64	44	20	40

Q5. Is education given in computer ergonomics (i.e. how to design a computer work station, how to sit, how to arrange lighting etc.)?				
	None	Limited	Extensive	(%)
Low grade	64	32	5	
High grade	63	37	0	
Junior high	31	64	6	
High school	60	32	4	

(notebook) models were more available in nearly 80% of the elementary schools. Cathode Ray Tube Displays (CRTs) for desktops and Liquid Crystal Displays (LCDs) for notebooks, both generally color were the most usual combinations.

Q14: Keyboards and a mouse were the typical input devices.

4. Questions concerning ergonomic considerations (Q15–Q19)

The results are shown in Table 4.

Q15–17: Desks and chairs specially designed for young people were adopted by 40% of the junior high schools and 20% each of the other groups. Height-adjustable desks were seldom used in any group, but height-adjustable chairs were common in junior high and high schools (90% each). Fixed-height chairs were used in more than 70% of the elementary schools.

Q18, 19: Consideration of lighting (e.g., the position of windows and lighting fixtures) was included by 40% of the elementary and high schools, and also by 60% of the

Table 2. Questions concerning how computers are used

Q6. Does your school have

- a. A special room for computers?
- b. Computers placed in classrooms?
- c. Computers placed in the vicinity of classrooms?
- d. Computers linked to nets within the school?
- e. Computers linked to external nets such as the INTERNET?

	a	b	c	d	e (%)
Low grade	45	23	41	18	50
High grade	34	17	34	11	40
Junior high	100	3	36	14	44
High school	92	0	20	28	60

Q7. How many computers are there in the school for student use?

	Number of computers	Computers per student
Low grade	13	0.09
High grade	12	0.06
Junior high	23	0.05
High school	50	0.05

Q8. How many students use a computer at the same time?

Normally one

Normally 2-3 together

Normally more than 3 together

	One	2-3	>3 (%)
Low grade	9	41	59
High grade	3	37	60
Junior high	6	94	0
High school	68	20	12

Q9. How long does - in your experience - a student normally use a computer in school each week?

	0-2	2-4	4-6	>6 hours/week (%)
Low grade	95	5	0	0
High grade	89	9	0	0
Junior high	92	6	0	3
High school	68	20	8	0

Q10. Can the students use the computers when they choose?

	Yes (%)
Low grade	41
High grade	34
Junior high	11
High school	28

junior high schools.

5. Questions concerning health (Q20-Q23)

The results are shown in Table 5.

Q20: Almost 50% in each group provided some instruction on working posture. As far as the junior high school group is concerned, nearly half were also giving some guidance as to the height of chairs and viewing angle. This group scored highest on the greater part of instruction-related questions.

Q21: Students complaining of eye pain or eye discomfort were reported in more than 20% of the junior high and high schools. The higher the grade, the greater the number of students experiencing these and other symptoms.

Q22: Regardless of school categories, almost half the

respondents observed that some pupils and students were apt to keep too short a viewing distance. The most conspicuous example of bad posture assumed by elementary and junior high children was that of slouching forward, whereas more than 30% of the high schools, in contrast, had noted such a far-backward posture that the user is virtually lying on his or her back.

Q23: The pupils and students complaining of eye problems were a low percentage, but steadily growing in number among higher graders.

Discussion

At the time of the survey in March 1998, the schools which

Table 3. Questions concerning computer equipment

What type of computers are in use? (You may respond to several alternatives if appropriate.)

Q11. "Normal" computers (i.e. one that normally stays in one place)—Desktop
Notebook (i.e. one that is normally carried around)

Q12. Is the most common a Cathode Ray Tube (TV-like)
....or a liquid crystal screen (LCD)
....or other(s)

Q13. Is it most common to have single colour screens (bl/w)
....or multicolour screens

	Q11		Q12		Q13	
	Desktop	Notebook	CRT	LCD	bl/w	multicolour (%)
Low grade	55	73	55	68	0	100
High grade	46	77	46	74	0	100
Junior high	100	8	100	8	3	100
High school	92	20	92	20	12	92

What type of equipment for data entry is used?

(You may respond to several alternatives if appropriate.)

Q14. Data entry is most often by use of

	Keyboard	Mouse	Trackball	Touchpad	Other (%)
Low grade	91	100	5	0	5
High grade	97	100	6	9	0
Junior high	100	100	3	3	3
High school	100	96	0	0	0

already introduced computer education accounted for around 40%, 90% and 70% of the elementary, junior high and high schools, respectively. The focus of teaching varies from one school group to another, but the percentage of schools which were "making positive efforts in computer education" was nearly the same in all the groups, about one tenth of the total. It is reasonably expected that the last few years have added to the above figures, giving a chance for more schools to start and get more actively engaged in computer education programs.

Regarding computer hardware, it is remarkable that more than 70% of the elementary schools were letting their pupils work with LCD-integrated notebook computers. Since notebooks tend to put priority on portability even when it could compromise comfort for users⁴⁾, it is desirable to switch to desktops if there is enough space in the classroom.

To take just a few examples, a desktop computer has a keyboard slightly tilted so that the tilt may mitigate the strain on the operator's hands, while a notebook type offers no

Table 4. Questions concerning ergonomic considerations

Q15. Do the students use tables and chairs designed for children?

Q16. Can the students normally adjust the table height?

Q17. Can the students normally adjust the chair height?

	Q15 Yes	Q16 Yes	Q17 Yes (%)
Low grade	18	0	27
High grade	23	3	20
Junior high	36	8	97
High school	16	4	88

Q18. Has window position been considered when placing the computers?

Q19. Has the position of lighting been considered when placing the computers?

	Q18 Yes	Q19 Yes (%)
Low grade	41	27
High grade	40	29
Junior high	50	67
High school	36	40

such comfort. Instead, the latter has, as Saito pointed out, not only the keyboard but also the display integrated into its main body, thus often causing the user to secure an easy access to the keyboard by placing it in a way that leaves only a short viewing distance⁹⁾. Moreover, views on LCDs are dependent on the viewing angle⁴⁾, that is, not clear or in proper colours when seen from oblique angles—a characteristic which becomes a disadvantage when one notebook is shared by more than two persons. Thus notebook computers with an integrated display and keyboard can therefore put heavier strain on the user's musculoskeletal and visual systems¹⁰⁾. Desktops with a CRT are preferable, especially if shared by two or more users at once.

Less than half of the schools were taking care to place displays with regard for their relative position to windows and lighting fixtures. Light would help, if viewed objects were something written on paper such as books or notebooks, but it would rather have adverse effects with CRTs or backlight LCDs. Being luminescent in their own right,

Table 5. Questions concerning health

Q20. Are the students given any advice when they use computers concerning

- Seating posture
- Chair height
- Table height
- Viewing angle
- Lighting
- Other advice

	a	b	c	d	e	f (%)
Low grade	45	14	5	27	18	9
High grade	49	14	6	20	17	14
Junior high	56	58	17	42	14	14
High school	36	12	4	28	16	16

Q21. Do students experience discomfort when using computers?

- Yes, eye discomfort
- Yes, neck or shoulder
- Yes, arm or hand
- Yes, back
- Yes, other _____
- No, I don't know of any

	a	b	c	d	e	f (%)
Low grade	5	0	0	0	0	95
High grade	6	0	0	0	0	91
Junior high	19	3	0	0	3	81
High school	24	4	8	0	4	68

Q22. Have you noticed body postures such as

- very short distance to the computer
- the student looks "upwards" to the computer
- "abnormal" neck position (head back)
- collapsed position (forward)
- extreme reclining position (half lying backwards)

	a	b	c	d	e (%)
Low grade	50	18	5	23	14
High grade	51	6	3	26	11
Junior high	72	3	8	22	14
High school	44	12	12	8	32

Q23. Have you noticed - in students - eye problems such as

- red eyes
- excessive tears
- frequent or intense eye rubbing
- difficulty in reading words and/or symbols

	a	b	c	d (%)
Low grade	0	0	5	0
High grade	0	0	0	6
Junior high	0	3	0	14
High school	4	4	0	16

displays, like TV, will have their visibility impaired by lighting. Glare caused by highly-luminescent reflections of windows or fluorescent tubes will become an inducement to eye fatigue. That is why such precautions should be taken as attaching adjustable window shades to gain appropriate lightness anytime, or seeking to avoid reflections by the desirable positioning of displays, windows and lighting fixtures.

Akutsu's report based on a survey regarding working postures of elementary pupils before computers mentioned unsuitable workstation conditions in view of children's physique: short viewing distance, feet hanging above floors, chair backs too far back to support the body¹¹⁾. Working for hours under such conditions will surely result in severe eyestrain, pressure on feet and heavy stress on back and shoulders.

Our survey also revealed that many elementary school pupils assume bending, head-forward postures with upward gaze (Q22), probably reflecting the situation where they are striving to see the displays set too high for children's eyes. Taptagaporn¹²⁾ and Sotoyama¹³⁾, having identified upward gaze as a source of extra physical strain which in turn causes pain and dryness in the eyes, recommended the use of height-adjustable desks and chairs that allow children to assume higher postures and look down on the screen.

In elementary schools, where smallness of the adoption ratio of height-adjustable chairs was especially noted, emphasis must be laid on creating a flexible environment that accommodates the needs of every young student. Such efforts must pay attention to the great difference in physique not only between lower and higher grades but also among individuals. Since this issue of physical individuality is common to other categories, it is desirable for all schools to introduce height-adjustable desks and chairs and provide each student with the most suitable computer operating environment.

This time the survey did not reveal any serious effects on the health of pupils or students. Presumably this is mainly because their use of computers did not exceed two hours a week in most of the schools.

According to the recent wide-ranging questionnaire survey covering a variety of job categories¹⁴⁾, approximately 80% of the working people were experiencing some form of physical fatigue or subjective symptoms that could be ascribed to the use of computers. If pupils and students should come to spend more school hours working at computers, it is possible that more of them will experience physical fatigue or other subjective symptoms. As an effective way to prevent such future situations, an installation

plan for computers should include the choice of chairs, desks, input devices and displays that meet the ergonomic requirements, as well as due consideration of the natural and artificial lighting. Even if some of these may not be feasible, for example, for financial reasons, knowing the ergonomic way of thinking will help to reduce body strain by using simple tools or ideas.

Conclusion and Future Agenda

Within the scope of this survey, those schools that were “teaching the pupils and students in an appropriate environment how to use a computer” accounted for 40% of the elementary and high schools and 60% of the junior high schools. On the other hand, less than 10% in each school category were doing that “actively”.

Now that the amount of computer time at home and school is sure to keep increasing, the important thing is to use the equipment in a well-designed environment, benign and attuned to human behavior, physiology and psychological features, in order to maintain users’ health. It would be most effective and useful for pupils and students to acquire in their classrooms the necessary knowledge for creating such an environment. But the guidelines for pupils and students¹⁵⁾ are very few. The current guidelines and international standards are possible teaching materials. But since they have been devised for adults, they are not always applicable to or detailed enough for young computer users. It is a matter of urgency that we develop new guidelines based on attention given to the physique and physiology of pupils and students.

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