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# COMPUTER LITERACY IN SECONDARY EDUCATION: THE PERFORMANCE AND ENGAGEMENT OF GIRLS

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**Abstract**—This research study examines performance and engagement in computer literacy of boys and girls ($N = 873$). Performance and engagement in computer literacy are established with CAST, Computer Alfabetisme Schalen Twente, a Dutch version of the Minnesota Computer Literacy Awareness Assessment. The results of the study show that girls perform lower and are less engaged in computer literacy than boys. Research on sex differences in mathematics and science education shows that three factors are important for the design of action programs for girls, viz. the expectation and behaviour of significant others, the perception of the usefulness of the subject for a future career and a positive attitude towards the subject. This study shows that these factors seem to be relevant for computer literacy too. It has been found that a positive attitude towards mathematics and physics is positively related to a positive attitude towards computer literacy. An examination of the relation between performance in computer literacy and attitude towards mathematics and physics shows no differences in performance between boys and girls with a negative attitude towards mathematics and physics. For boys and girls with a positive attitude towards mathematics and physics however a difference in performance in computer literacy has been found in favour of boys.

## INTRODUCTION

Sex equality in computer literacy is an important issue for teachers, policy makers and researchers now that computers are coming into Dutch schools. Recent American studies show that the performance of girls in computer literacy and computer science is lower than that of boys [1–3]. An evaluation study in the Dutch context shows that teachers think that girls perform lower and are less engaged in computer literacy [4]. No Dutch studies to date however have been conducted on the performance and engagement in computer literacy of girls and boys.

Studies concerning factors which may have a bearing on the differences between girls and boys in computer literacy and computer science correspond with research on sex differences in mathematics and science education. Meece *et al.* [5] found in a review of research studies on sex differences in mathematics education three factors which were connected with the performance in mathematics and/or the choice for mathematics in high school, viz. the expectation and the behaviour of significant others such as parents, teachers and peers; the usefulnes for a future career; and a positive attitude towards the subject.

In research on sex differences in mathematics and science education it is found that boys are more encouraged by their parents, teachers and peers [5, 6]. Research on this issue in the field of computer literacy and computer science shows that students, girls and boys, do not perceive a difference in encouragement by their parents [7, 8] and teachers [8, 9]. Girls and boys do however perceive a difference in encouragement by peers. Boys state that they are more encouraged by their peers than girls are [7, 8, 10, 11].

Research on the usefulness of knowledge of computers for a future career shows that girls and boys think that knowledge of and experience with computers are important for their future careers [2, 3, 8, 9, 12]. It has also been found however that boys have more concrete plans to take a computer course or consider a career as a computer specialist [2, 8, 12].

With respect to differences in attitude between girls and boys towards computers the results of research studies are not clear. Some studies found a more positive attitude of boys towards computers [1, 2, 10, 11]. Fetler [3] however found that the attitude of both girls and boys is, generally speaking, positive. Some studies report about different aspects of attitudes towards computers. Collis [13] found that boys show a higher interest in computers than girls. Results of

a study of Miura [10, 11] showed that girls consider themselves less competent in dealing with computers. Campbell [14] found no differences between girls and boys in computer anxiety.

Mathematics and science are perceived by both boys and girls as belonging to the male domain. Although boys and girls declare that computer literacy and computer science is not a male domain subject [7, 9, 12, 13, 15] computers are most often used in the mathematics and science lessons [12] and computer literacy is taught by mathematics and science teachers [4]. Further, computer science finds its origins in mathematics. An association of computer literacy and computer science with mathematics and science is therefore possible.

The study reported here has an exploratory character and examines whether in the Dutch context girls are less engaged and perform less well in computer literacy than boys. The factors Meece *et al.* [5] consider relevant for sex differences in mathematics education have been taken as a starting-point. It is hypothesized that these factors, viz. the expectation and the behaviour of significant others, the usefulness for a future career and a positive attitude towards the subject, are relevant for computer literacy too. Next to this the study examines whether a positive attitude towards mathematics and science is related to performance and engagement in computer literacy. The following hypotheses have been tested:

Concerning performance and engagement:

1. Boys perform higher in computer literacy than girls.
2. Boys enjoy dealing with computers more than girls.
3. Boys feel more confident about their abilities to deal with computers than girls.
4. Girls feel more anxiety dealing with computers than boys.

Concerning encouragement by others:

5. Boys are more encouraged by their parents to engage in computers than girls.
6. Boys are more encouraged by their teachers to engage in computers than girls.
7. Boys are more encouraged by their peers to engage in computers than girls.

Concerning usefulness for future careers:

8. Boys expect more than girls to use computers in their future careers.

Concerning relations between physics/mathematics and computer literacy:

9. Boys and girls having a positive attitude towards physics and mathematics are more engaged in computer literacy.
10. Boys and girls having a positive attitude toward physics and mathematics perform higher in computer literacy.

## METHOD

*Instrumentation*

A Dutch version, called "Computer Alfabetisme Schalen Twente" (CAST) of the Minnesota Computer Literacy Awareness Assessment [16] has been used. Like the Minnesota Computer Literacy Awareness Assessment the questionnaire consists of three components: an affective test*, a cognitive test and a survey of background variables. The affective test is a translation of the original items and can therefore be compared wth the Minnesota Computer Literacy Awareness Assessment. The cognitive test consists of a much smaller number of items than the original instrument. For CAST there are no data concerning the validity and reliability of the instrument. For a first exploratory survey however this is considered to be acceptable.

The sex-typing scale (5 items) has been used to establish to what extent girls and boys perceive computers or computing as a male domain.

*For this research study the educational computer support scale and the policy concern scale, although administered, were not used.

The engagement of girls and boys in computer literacy has been measured through the enjoyment-scale (5 items), the anxiety-scale (5) and the efficacy-scale (4). These affective scales are described below:

*enjoyment*—The degree to which a student enjoys computers or learning about computers.
*anxiety*—the level of anxiety or stress that is associated with computers.
*efficacy*—the extent to which a student feels confident about his or her ability to deal with computers.
*sex-typing*—the tendency to see computers or computing as a male domain.

The performance of boys and girls has been measured by the cognitive test of CAST (25 items). This test consists of items on programming and algorithms (4), software and data processing (5), computer mystique (5) and applications (11).

For this survey background variables on encouragement by parents, teachers and peers; the attitude of pupils towards physics and mathematics; and the perception of the usefulness of knowledge of computers for future careers were collected.

*Sample*

The sample consisted of twenty schools out of a hundred schools participating in an experiment on computer literacy. Stratification was based on school type. The age in the sample varied between 12 and 16. The tests were administered by classroom teachers during normal class time. The responses of 873 students ($N = 873$, 419 female and 454 male) could be used for the study. Table 1 shows the desired and actual composition of the sample.

*Analyses*

The reliabilities of the affective scales and the cognitive test have been established by means of Cronbach's alpha. The intercorrelations of the affective scales have been computed. The sample is large enough to suppose normality. Hypotheses concerning performance and engagement in computer literacy (1–4) were tested with Student's $t$-test (one-sided). A level of significance $\alpha = 0.05$ was chosen.

Where necessary a correction has been made for unequal variances. Hypotheses concerning the influence of significant others and the perception of usefulness of knowledge of computers for future careers (5–8) have been tested with the Chi-square test with a $\alpha = 0.05$ level of significance.

Hypotheses concerning the relationshps between physics, mathematics and computer literacy (9–10) were tested with two-way analysis of variance executed with regression analysis, as a result of unequal cell sizes. A level of significance $\alpha = 0.025$ was chosen, so that the level of significance for the family of tests is $\leqslant 0.075$ (Bonferonni's inequality).

For hypothesis 9 engagement is operationalized in the three aspects which have been mentioned: enjoyment, anxiety and efficacy. Some analyses supplementary to the testing of the hypotheses have been executed.

## RESULTS

*Reliability*

Table 2 shows the alpha reliabilities of the affective scales and the cognitive test. As a result of the validation results [17] some items of the Minnesota Computer Literacy Awareness Assessment

Table 1. Number of participating schools (desired and actual) and number of participating students

| | Number of schools | | Number of students | |
|---|---|---|---|---|
| | Desired | Actual | Female | Male |
| LBO (junior vocational training) | 6 | 6 | 85 | 168 |
| MAVO (junior secondary general education) | 4 | 4 | 87 | 65 |
| HAVO (senior secondary general education) | 4 | 3 | 87 | 80 |
| VWO (pre-university education) | 4 | 2 | 55 | 43 |
| VbaO (comprehensive or middle school) | 2 | 2 | 33 | 41 |
| BRUGKLAS AVO (transition year secondary general education) | — | 2 | 51 | 37 |
| BRUGKLAS AVO/LBO (first year secondary general/vocational education) | — | 1 | 21 | 20 |
| Total | 20 | 20 | 419 | 454 |

Table 2. Reliabilities of CAST in comparison with the Minnesota Computer Literacy Awarenes Assessment

| | CAST | MCLAA |
|---|---|---|
| Cognitive test* | 0.77 | 0.89 |
| Enjoyment scale | 0.81 | 0.83 |
| Anxiety scale | 0.55 | 0.74 |
| Efficacy scale† | 0.68 | 0.68 |
| Sex-typing scale | 0.79 | 0.74 |

*A comparison is not possible, due to an unequal number of items.
†After omitting one item.

Table 3. Intercorrelations affective scales

| | Enjoyment scale | Anxiety scale | Efficacy scale |
|---|---|---|---|
| Enjoyment scale | 1.00 | | |
| Anxiety scale | −0.36 | 1.00 | |
| Efficacy scale | 0.43 | −0.23 | 1.00 |

(MCLAA) have been omitted. These items were however still present in CAST. Through removal of one item of the efficacy scale a higher alpha reliability was acquired. Removal of one item in the sex-typing scale did not increase the reliability. The alpha reliability of the anxiety scale appears to be very low, therefore further analyses with this scale must not be taken too seriously. Taking the length of the scales into account the alpha reliabilities of the other scales are considered to be acceptable.

Table 3 shows the intercorrelations of the affective scales. The intercorrelations are low and in the direction expected. The aspects of engagement could therefore be considered as separate components.

*Performance and engagement*

The results concerning performance and engagement in computer literacy (hypotheses 1–4) are shown in Table 4. Boys perform higher on the cognitive test, they show more pleasure, have more confidence in their efficacy and show less anxiety dealing with computers than girls do. All results are statistically significant ($P < 0.001$), so hypotheses 1–4 are not rejected.

*Encouragement by significant others*

Table 5 shows the perceived encouragement by significant others (hypotheses 5–7). A fairly high percentage of the students state that they are not encouraged by their parents, teachers and peers (68, 70 and 86% respectively). Boys however perceive that they get more encouragement by parents ($\chi^2 = 4.09$, df = 1, $P = 0.04$) and peers ($\chi^2 = 32.26$, df = 1, $P = 0.00$) than girls do. With regard to encouragement by teachers the results are not statistically significant ($\chi^2 = 2.14$, df = 1, $P$ = ns). So, hypotheses 5 and 7, concerning the encouragment by parents and peers are not rejected, while hypothesis 6, concerning the encouragement by teachers is rejected.

*Usefulness for a future career*

The results on perceived use from computers in future jobs is shown in Table 6 (hypothesis 8). 60% of the students expect to use the computer in future jobs. The difference between male and

Table 4. Performance (cognitive test) and engagement (enjoyment scale, anxiety scale and efficacy scale) in computer literacy

| | Female ($N = 419$) | | Male ($N = 454$) | |
|---|---|---|---|---|
| | $\bar{X}$ | $SD$ | $\bar{X}$ | $SD$ |
| Cognitive test | 13.60 | 4.45 | 15.07 | 4.38 |
| Enjoyment scale | 18.56 | 4.06 | 21.26 | 3.46 |
| Anxiety scale | 9.65 | 2.94 | 8.71 | 2.84 |
| Efficacy scale | 15.86 | 2.88 | 17.23 | 2.95 |

Table 5. Encouragement by significant others (%)

| | Encouragement by parents | | Encouragement by teachers | | Encouragement by peers | |
|---|---|---|---|---|---|---|
| Sex | Yes | No | Yes | No | Yes | No |
| Female | 28.8% | 71.2% | 27.1% | 72.9% | 7.2% | 92.8% |
| Male | 35.5% | 64.5% | 31.9% | 68.1% | 21.2% | 78.9% |

Table 6. Usefulness for future career (%)

| | Career usefulness | | |
|---|---|---|---|
| Sex | Yes | No | Total |
| Female | 47.3% | 52.7% | 100% |
| Male | 71.8% | 28.2% | 100% |

Table 7. Engagement and performance in computer literacy in relation to sex and attitude towards maths and physics

| | Mathematics F | | Physics F | |
|---|---|---|---|---|
| Enjoyment scale: | | | | |
| Interaction sex × attitude | 1.69 | NS | 2.74 | NS |
| Main effect sex | 49.23 | *** | 23.58 | *** |
| Main effect attitude | 13.10 | *** | 7.48 | *** |
| Efficacy scale: | | | | |
| Interaction sex × attitude | 0.71 | NS | 1.23 | NS |
| Main effect sex | 18.27 | *** | 20.07 | *** |
| Main effect attitude | 4.60 | ** | 3.08 | * |
| Cognitive test: | | | | |
| Interaction sex × attitude | 2.91 | * | 4.43 | ** |
| Main effect sex | 10.64 | ** | 7.49 | * |
| Main effect attitude | 5.27 | *** | 4.93 | *** |

***$P < 0.001$; **$P < 0.005$; *$P < 0.025$.

female students is statistically significant in favour of boys ($\chi^2 = 51.48$, df $= 1$, $P = 0.00$), so hypothesis 8 is not rejected.

*Attitude towards mathematics and physics*

Hypotheses 9 and 10 are concerned with the relationship between the attitude towards physics and mathematics and engagement (enjoyment scale, anxiety scale and efficacy scale) and performance (cognitive test) in computer literacy. Table 7 shows the results. A graphical display of the results on the enjoyment scale and the cognitive test is given in Figs 1 and 2. The anxiety scale is difficult to interpret. Because of the low alpha reliability of this scale it will not be considered further.

In conformity with the results of the testing of hypotheses 1–3 a statistically significant main effect of sex has been found for the enjoyment scale, the efficacy scale and the cognitive test. A statistically significant main effect for the attitude towards physics and a statistically significant main effect for the attitude towards mathematics have also been found for the affective scales and the cognitive test.

Figure 1 shows that a positive attitude towards physics and mathematics is related to having more pleasure in dealing with computers. Although to a lesser extent a positive attitude is also related to feeling more confident in dealing with computers.

A statistically significant interaction effect has only been found for the cognitive test. This is the case for physics and mathematics. No differences in performance between boys and girls with a negative attitude towards physics and mathematics have been found. When a positive attitude

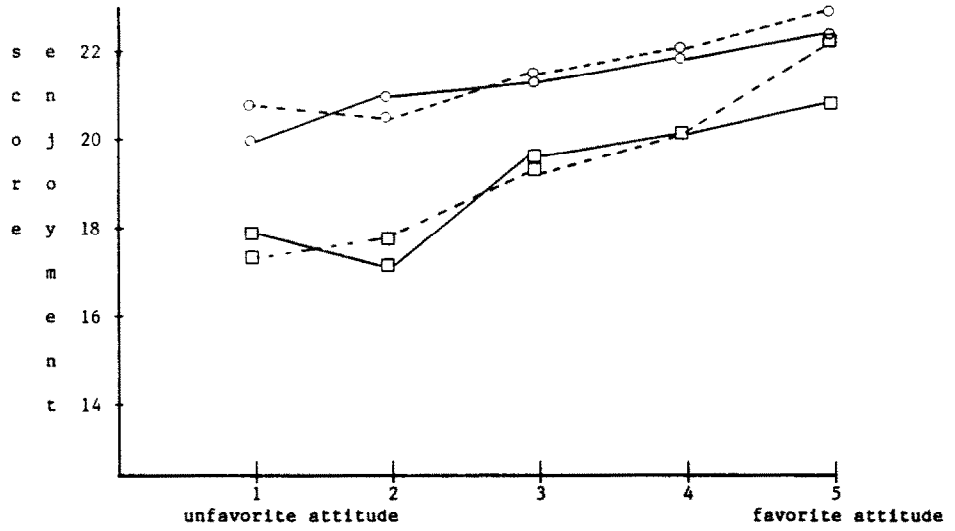


Fig. 1. On the enjoyment scale related to the attitude towards mathematics (---) and physics (——) and sex (○: boys; □: girls).

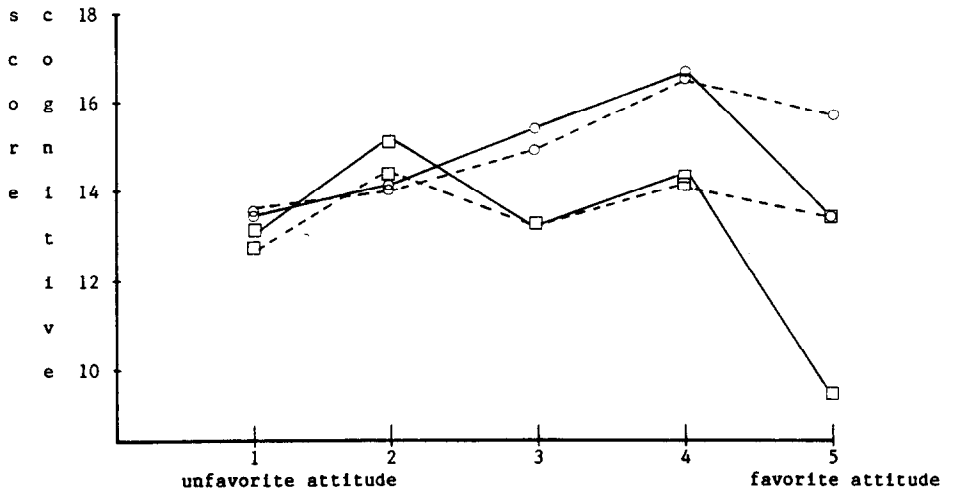


Fig. 2. Score on the cognitive test related to the attitude towards mathematics (---) and physics (——) and sex (○: boys; □: girls).

prevails, differences in performance are however found in favour of boys (Fig. 2). The most positive attitude towards physics and mathematics are—for both girls and boys—related with low performance in computer literacy. A theoretical explanation for this is difficult to provide.

The parallelism between physics and mathematics is striking. It suggests that students consider these subjects as belonging to the same domain.

*Supplementary analyses*

With a view to further interpretation of the results of the testing of the hypotheses some supplementary analyses have been carried out in relation to the extent computers are perceived as belonging to the male domain, the time spent on the keyboard and the most appreciated activities which take place during computer literacy lessons. The results are presented below:

* The mean score on the sex-typing scale is low (mean score = 8.14). The score for boys (mean score = 9.11) is however significantly higher ($t = -9.98$, df = 843, $P = 0.00$) than the score for girls (mean score = 7.08) on this scale.
* More boys (46.9%) than girls (31.7%) spend more than 20 hr on the keyboard. This includes computer use both in and out of school.
* Both boys (86.6%) and girls (89.1%) like most activities with the computer in computer literacy lessons.

## DISCUSSION

This study shows that boys perform better in computer literacy, enjoy computers more and feel more confident about their ability to deal with computers than girls do. Boys are also less anxious than girls. Through the low reliability of the anxiety-scale however too much importance should not be attached to the results on this scale. The higher performance of boys on the cognitive test is in accordance with the results of several other studies [1–3]. The difference may be due to the fact that boys have more experience with computers in comparison to girls, as has also been found by other studies [7, 10, 18, 19]. Research on sex differences in mathematics and science education also shows that boys have more—for these subjects relevant—experience [20]. Further research on the impact of (different types of) experience however is necesary. From the higher engagement of boys in computer literacy it can be concluded that the attitude of boys towards computers is more positive than the attitude of girls. The computer is an essential part of most computer literacy lessons and girls and boys like these lessons most when activities with the computer have to be done. The more positive attitude which has been found for boys is in accordance with the study of Lockheed *et al.* [1, 2]. Studies from Miura [10, 11] concerned with the differences between girls

and boys on feeling more confident about computers show the same results as have been found in this study. Our study found that boys are more encouraged by parents and peers to engage in computers than girls are, as has been found in research on sex differences in mathematics education [6].

Boys however do not declare that they are more encouraged by teachers than girls are to engage in computers. Jungbluth [21] found in his study that a different behaviour of teachers towards boys and girls can be expressed in different expectations they have towards boys and girls. Then open en- or discouragement is less clear. What is striking however is that most of the respondents state that they are not encouraged by their teachers. A still relative lack of acquaintance and accessibility of computers in Dutch schools may be an important factor. As has been found in research concerning the perceived usefulness of mathematics and science for a future career [5, 6] this study shows that more boys than girls expect to use computers in their future jobs.

Neither girls nor boys perceive the computer as belonging to the male domain, but this does not seem to say anything about their factual behaviour; the career expectations reflect a traditional pattern, which has been found by Fennema [22] in a study concerning mathematics as well. Next to the important impact of sex, the attitude towards mathematics and physics also appears to be important for engagement in computer literacy. The more positive the attitude toward mathematics and physics the more students enjoy dealing with computers and the more students feel confident about their ability to deal with the computer. This suggests an affective association of computer literacy with mathematics and science. The results of the study show that there are no differences in performance in computer literacy between girls and boys with a negative attitude towards mathematics and physics. When the attitude towards mathematics and physics is positive however a difference between boys and girls has been found in favour of boys. Further research on the relation between performance in mathematics and science and the performance in computer literacy is necessary.

In summary, it can be concluded that the results of this study support most of the hypotheses, except the hypothesis concerning the encouragement by teachers and the hypothesis stating that a positive attitude towards mathematics and physics is related to higher performance in computer literacy.

Sex equality in computer literacy seems to be an important issue. The factors Meece *et al.* [5] consider important for the design of intervention strategies, viz. the encouragment by significant others, the usefulness of the subject for a future career and a positive attitude towards the subject are probably important for computer literacy as well.

Research and development on sex equality can start with the results of research on sex differences in mathematics and science education. Research and development in this field is focused on the education of teachers, the development of sex-fair and, for girls, attractive curriculum materials, the development of career choice programs, especially for girls and class environment and instructional strategies.

Computer literacy in the Dutch context however is aimed at an integral approach of new information technologies in society, so that it is necessary to take this characteristic of computer literacy into account.

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