MEASURING THE STOCK OF EDUCATIONAL CAPITAL BY THE COSTS OF EDUCATION.

ESTIMATES FOR NORWAY 1950 AND 1960[1]

By

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1) This paper is a shortened and revised version of my Norwegian papers
   Hoffmann, 1968a and b, which are based on my thesis for the economics
   degree cand.oecon. at the University of Oslo. The Department of
   Research of the Central Bureau of Statistics of Norway has kindly
   given me the opportunity and means to work with these problems. I
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   errors and omissions rests solely with the author.

1. INTRODUCTION

The stock of human capital ·· H ·· in a sector may be expressed as

1.1   H = H(the number of persons; their education, past experien-
            ces, health, nutrition, age distribution.)

This paper is based on the assumption that for many purposes it is possi-

ble and useful to isolate a part of H ·· a part which is determined by

the education of the persons in the sector, This part we shall call "the

stock of educational capital" ·· U.

Our point of view shall be that of a planning agency wishing to

measure U in order to investigate the influence of U ·· and subgroups of

U ·· on the production of the sector and U's role in determining the pro-

duction possibilities of the sector. The planning agency will be inter-

ested in knowing the costs of obtaining U ·· as well as the costs of add-

ing to the stock ·· in order to be able to relate them to the benefits.

However, as no physical measure of educational capital exists, it should

also be of some interest to examine the conditions under which the costs

of obtaining the educational capital would give us an unambigous measure

of U. Following a discussion on the problems of using the costs to

measure U some estimates of the stock of educational capital of Norway

in 1950 and 1960 will be presented. These estimates are rough calcula-

tions using essentially the approach of T.W. Schultz, 1960, and they

have ·· as does the discussion ·· an explorative nature.[1]

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1) See Machlup, 1962, and Hoffmann, 1968a, for discussions of the con-
    cept of education and its various forms. In this paper I am ·· for
    the sake of convenience ·· only dealing with educational capital pro-
    duced in schools. "Education" and "the production of educational
    capital" may be regarded as equivalent terms in this paper.

2. PROBLEMS OF USING THE COSTS OF EDUCATIONAL CAPITAL.

As we have no markets for pieces of U, the costs of obtaining educational capital will have to be measured by the costs of production. The most important factors of production being the services of teachers, students and real capital, the task is $\underline{a}$ to specify the conditions on the production function and the behaviour of the educational sector necessary for the costs of these services during a period to give us a measure of the amount of educational capital produced during this period so that we may compare this with and add to educational capital produced in other periods (or places) and measured in the same way; and $\underline{b}$ examine to what extent these conditions hold true for the educational sector. Neither the space nor the state of the science allow me to deal exhaustivly with these tasks and it may be that the last one mainly belong to the educators and psychologists but let me make some remarks on them.

From the economic theory of production we know that the conditions mentioned above must create a situation where it is so that whenever the produced amount of educational capital during a period are to be changed, the amounts of inputs used have to be changed in the same proportion. One class of production functions which one may be willing to accept for the educational sector is

2.1
$$\frac{u}{e} = u(\frac{l}{e}, \frac{k}{e})$$

This is a constantreturnstoscale production function saying that the amount of educational capital per student $(\frac{u}{e})$ produced during a period is a function of the amount of teacher and real capital services per student $(\frac{l}{e}$ and $\frac{k}{e}$ respectivly).

Assuming 2.1 and that production is optimized also with regard to the number of students for example by maximizing production

subject to a cost constraint, we will get

2.2 $$du = p_e e + p_1 l + p_k k$$

p_e, p_1 and p_k being the prices of the inputs. This follows from the Euler-equation of a homogenous function of the first degree since we in the optimum position will have

$$\frac{\partial u}{\partial e} = \lambda p_e, \quad \frac{\partial u}{\partial l} = \lambda p_1 \quad \text{and} \quad \frac{\partial u}{\partial k} = \lambda p_k, \quad \text{where} \quad \lambda = \frac{1}{d} \quad \text{is}$$

the Lagrange multiplier. With constant relative prices 2.2 will describe a straight line through the factor space along which there will be proportional factor variation and all marginal and average productivities and d will be constant. Under these restrictive conditions we may use the costs of production - properly defined - as a measure of the amount of educational capital produced during a period.

Let us look briefly at these conditions:

a The discussion in Norway on the advantages and disadvantages of "small" and "large" schools and the "right size" of a university may indicate belief in a structure of production somewhat like the "regular ultra-passum law of production" of Frisch, 1965. Constant returns to scale does, however, not sound too impossible as an assumption and is a standard one in most economic theory. Ultimately the question is an empirical one.[2]

b At most schools only a fixed number of students will be admitted at a time. The number is usually determined "with consideration to sound

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2) I am unfortunately not familiar with the discussions and studies of the educational production function by noneconomists. Katzman, 1968, and Bowles, 1968, have done some efforts to study educational production functions empirically, but have not dealt with the aspects discussed here.

and efficient instruction" but this will of course only be optimizing be-
haviour in the sense used above if the costs of the students' services --
$p_e e$ -- are included in the budget to which the school adjusts, and this
seems unlikely.[3]

c Relative prices are not likely to stay constant over a longer period of
time, and with substitution between factors of production we will be in the
well known bog of index-number problems. With only gradual changes in re-
lative prices, however, and the other conditions fullfilled, the use of a
Divisia-index would give an acceptable approximation.[4]

The purpose of imposing the restrictions which gave us 2.2, was
to ensure that the substitution possibilities of 2.1 would not be utili-
zed. One may therefore say that that we could just as well have assumed
a production function of fixed coefficients and limitation factors. We
should then also have to assume that the relative waste of resources
does not change over time or between schools to use costs -- at constant
prices -- as a measure of the educational capital produced. The introduc-
tion of television in the classrooms and the view -- not unchallenged --
that the introduction of an additional student in a class may reduce the
benefits to the others, do, however, in my opinion make it difficult to
rule out a priori the substitution possibilities.[5]

3. PROBLEMS WHEN MEASURING THE COSTS OF STUDENTS' SERVICES.

The interpretation of the cost-component $p_1 l$ as the teachers'
wages is fairly straightforward. $p_k k$ we may interprete as the costs of

3) This need of course not be the official budget of the school, as most
    schools do not pay their students any wages.

4) See Jorgenson & Griliches, 1967, for a discussion of this index and
    for further references.

5) Both Svennilson, 1961, and Seers & Jolly, 1966, seem to do so.

the services of the real capital (buildings and equipment) -- not so straightforward to measure, but thoroughly discussed elsewhere[6] -- and such costs which the students would not have had if they had not been under education. Not saying any more about these costs items a little more attention will be given to the meaning and measurement of $p_e e$.

When in the educational sector the student utilizes the services from his human capital to produce educational capital and is barred from using these services in activities which wuold have brought him income.[7] The student may measure his income foregone by the average income for economically active persons of the same age and with the same educational background -- and may correct for the probability of being unemployed; but from the society's point of view this need not be the correct expression of the value of his services. This may be illustrated by the following reasoning -- using greatly simplifying assumptions:

<u>a</u> We have an economy with perfect competition in all markets, and as one factor of production we have the services of persons chosing between employing them in the production of marketable goods or in the production of educational capital. The static market equilibrium in this economy will be one in which the value of the marginal productivity of this factor is the same in all uses of the factor, and thus the observed value (wage rate) of the services of the persons employing them in the production of goods should also be the value of this kind of services in the production of educational capital. We could use the procedure of the above mentioned student.

The conditions for perfect competion being rather restrictive, let us take a look at those violations which are most relevant in this context.

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6) See for example Jorgenson & Griliches, 1967.

7) Or he is barred from using the services for consumption in his spare time. Whichever it is does not change the argument.

b In those parts of the educational system where there is free entry there
will be no "producer" to optimize the production. To the extent that the
educational capital is subsidized for the students (the "buyers"), this
may lead to a market solution differing from that of a on the following
accounts[8]: (1) The value of the marginal productivities of the students will
be lower, as under a it is implicitly assumed that the educational capital
is not subsidized. (2) The value of the services of the non-students in
the goods-producing sector will be higher — as not so many are employed in
this sector. (3) It follows from (1) and (2) that the average wage rate
of the non-students in this case will overstate the value of the services
of the students. The extent of overvaluation will depend upon how price
elastic is the students' demand for education and how fast the marginal
productivities in the two sectors change.

c Where there is restricted entry the educational authorities will determine
the number of students admitted considering the "demands of an efficient educa-
tion". The reasoning of b does therefore not apply if there are more app-
licants than admissions. But — the determination of the number of students
will only be in accordance with a if the "producers" optimize and the costs
of the students' services enter the schools' budgets. If this is not the
case, the student number may all the same be close to what it would have
been if a, or it may be that even fewer are admitted, so that we by using
the non-students' wage-rates undervalue the marginal products of the
students.

To adjust for the probability of the students being unemployed —
as T.W. Schultz, 1960, did — seems to be irrelevant in this context. The
opportunity costs of the students services to the society is of course
zero when there is unemployment in the groups recruting students — even if

8) We assume all production functions to be continuous and twice differ-
   entiable, and that they have falling marginal productivities.

we are not willing to regard studies as productive activities. The level
of activity in the economy at the time of production of the educational
capital is of no interest to the extent That it does not influence its
ability to render services later on.

4. CALCULATING THE STOCK OF EDUCATIONAL CAPITAL.

Estimating the stock of educational capital for the U.S., Schultz,
1960, used replacement costs and the formula

$$4.1 \qquad U_{iT}^{(1)} = c_{iT} N_{iT}$$

(U_{iT} is the stock of educational capital of type i at time T, N_{iT} is the
number of persons at time T having completed education i and c_{iT} are the
costs per student at time T to produce educational capital of type i.)
With N_{iT} consisting of persons from many age groups U_{iT} will consist of
items which were produced over a wide span of years — during which the
reality behind the label i most certainly has changed. Using the costs of
production at T we may then get an entirely false picture of the resources
needed to replace that part of the stock which was not produced recently.
If neither the relative prices nor the overall productivity of the educa-
tional sector has changed substantially over time, we may instead use the
historical costs — adjusting for price changes — and write

$$4.2 \qquad U_{iT}^{(2)} = \sum_t c_{it} n_{itT}$$

(n_{itT} is the number of graduates at time t with education i who have sur-
vived until time T.) To the extent that we belive we know something about
the changes that have taken place, we may prefer to correct explicitly for
vintage effects:

$$4.3 \qquad U_{iT}^{(3)} = c_{iT} \sum_t n_{itT} h_{it}$$

where h_{it} is the vintage correcting factor.

4.1 - 4.3 give estimates only for a single point of time using for example the results of a population census. Not having data of this kind for every year and wanting to estimate time series, we may use a perpetual inventory method of estimation. The initial stock which existed at time T_o will at T be

$$\sum_{t'} c_{it'} n_{it'T}$$

and adding the vintages of the period from T_o to T we get

4.4 $$U_{iT}^{(4)} = \sum_{t'} c_{it'} n_{it'T} + \sum_{t} c_{it} n_{itT} \qquad (T = T_o + 1, \ldots \ldots)$$

(t' are points of time previous to T_o), and combining this with an adjust-ment for vintage effects and for the combined effects of the maturing and depreciation of the educational capital over time we shall get

4.5 $$U_{iT}^{(5)} = \sum_{t'} c_{it'} h_{it'} n_{it'T} \prod_{oj} f_{it'j} e_{it'j} +$$

$$\sum_{t} c_{it} h_{it} n_{it} \prod_{j} f_{itj} e_{itj} \qquad (T = T_o + 1, T_o + 2, \ldots\ldots)$$

4.5 is just an elaboration of 4.4 where I have included that $n_{it'T}$ may have to be estimated from $n_{it'T_o} \prod_j f_{it'j}$ where $f_{it'j}$ is the probability of surviving from time $j-1$ to j if you have the education i and gra-duated at time t' (assuming that this unambigously determines the persons age). As a correcting factor for the combined effect of the maturing and depreciation of the educational capital from $j-1$ to j ($j = T_o + 1$, $T_o + 2, \ldots\ldots, T$) I have included the term e_{itj}. Increased experience and on-the-job training we may for example want to treat as maturing and the loss of skills and knowledge as depreciation (Hoffmann, 1968a).

It is fairly simple to see how formulas like 4.4 and 4.5 may be extended into Markov-chain like forecasting formulas, as the forecasts on the survival probabilities usually are fairly accurate. Forecasts on the costs and the number of graduates - which to some extent may be determined by the planning agency - are of course more uncertain, as are estimates on

the h and e correcting factors.

5. PRESENTING SOME ESTIMATES FOR NORWAY, 1950 AND 1960.

In order to illustrate a possible order of magnitude of the stock
of educational capital in Norway in 1950[9] and 1960 some rough calculations
have been made. They are based on 4.1, using for both years the costs per
pupil in the school system during the school-year 1959/60 as weights.[10]
Estimates were made for four different groups of general education and 74
different groups of vocational education which in the tables are aggregated
into 12 main categories.[11] As no corrections have been made for effeciency
changes in the educational production functions over time or changes in the
realities behind the school labels, all measured changes between 1950 and
1960 are due to changes in the number of educated persons and in the dis-
tribution on the school groups.

According to these calculations the stock of educational capital
in Norway in 1950 and 1960 was 37 and 45 billion Nkr. respectivly; com-
pared to stocks of real capital of 95 and 143 billion Nkr. This means
that there was a drop in the share of the educational capital in the total
stock of capital of Norway from 35 percent in 1950 to 23 percent in 1960.
Schultz's figures give the share of the educational capital in the total
U.S. capital stock as about 40 percent in both 1950 and 1957.

In table A.1, the first three columns, first row, I have presented

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9) This is the first year for which the Census of Population gives date
on education.
10) It is mainly a lack of data which has prevented my use of the more
ambitious formulas presented above, but I am now (summer 1969)
working on calculations using formulas like 4.4 and 4.5.
11) These calculations seem to differ from those of Schultz, 1960, in the
following respects: a They seem to be more disaggregated. b Schultz
adjusted income foregone for the probability of the student being un-
employed. c Schultz was able to distinguish between the current costs
and the investments of the schools, and to estimate som costs of real
capital, whereas I have been forced to calculate as if the investments
in real capital in the educational sectors in 1959/60 were equal to
the costs of capital services that year

the number of persons 15 years old or more- all of whom were assumed to
have completed primary school. In the following rows the population is
distributed according to their highest general education above primary
school and their highest and second highest vocational education.[12]
The total stock of educational capital has in the last three columns been
distributed among the different educational categories on a "value added"
basis. This means that for each educational category only that part of
the total stock is given which has been "produced" in schools of that cate-
gory.[13] The rates of change given for the educational capital are differ-
ent from those of the corresponding number of persons only to the extent
that there were changes in the group compositions of the categories, as
pointed out above.

Table A.2 gives the relative shares of the educational categories.
There was no change in the relative importance of general and vocational
education, but there was some shift towards the categories of higher gene-
ral education and those vocational categories which are based on them.

In table B we have split the stock of educational capital accord-
ing to components of costs. We assumed that there was no income foregone
during the years of primary schooling. For most other groups income fore-
gone was the most important component of costs.

Using the activity rates by education for the population we have
calculated the amount of educational capital actually at use in

12) In the 1950 Census it was asked for all vocational courses and schools
   of 5 months duration or more, whereas in 1960 only those lasting for
   at least 10 months were to be included. This means that for some edu-
   cational categories - i.e. a, b, c, j and k of table A.1 - the figures
   are not really comparable. As we are using the prices and cost con-
   ditions of the school-year 1959/60, changes in the stock of educatio-
   nal capital will on this account be negativly biased, but the impact
   on the totals is minor- not more than 1 or 2 percents - as the educatio-
   nal groups in question do not carry much weight in the totals.
13) There are some conseptual difficulties with this approach which I have
   discussed more closely in Hoffmann, 1968a.

production.[14] From table C we see that the increase in the stock of em-

ployed educational capital between 1950 and 1960 is much stronger than the

increase in the working population, but not as strong as the growth of the

total stock of educational capital. This may be an indication that the

growth in the stock of educational capital as here measured cannot have

been a dominating factor in the economic growth of Norway during the 1950s[15].

In table D the stock of educational capital per capita according

to age group is given. When comparing the age groups one should bear in

mind that at the time of the census those in the youngest age groups had

not yet completed their education. Those who in 1950 were 15 - 19 years

old and in 1960 were 25 - 29 years old had for instance an increase in

their per capita stock of educational capital from 11 to 20 thousand Nkr.

Of this increase 4 000 Nkr. were "due to" increased general education and

5 000 "due to" an increase in vocational education.[16] The figures of

table D seems to indicate that a growth in the stock of educational capital

substantially higher than the growth in the adult population is mostly a

phenomenon of the postwar period.[17][18]

6. CONCLUDING REMARKS.

In this paper I have tried to present some of the problems one has

to face and some of the assumptions one ought to make when estimating the

stock of educational capital by the costs of education, as well as

14) By this meaning the amount of educational capital employed in activi-
ties registered in the national accounts. Unemployment was almost nil
in both years.

15) Denison's, 1967, results give the same conclusion. For a review of
the Norwegian economy after 1945 see Central Bureau of Statistics,1965.

16) By including the education started but not completed by those in the
age group 15 - 19 in 1960, the stock of educational capital per person
in this age group would be about 20 000 Nkr. By now the persons in this
group in addition have got educational capital from educations not yet
started in 1960.

17) Schultz's figures give a per capita stock of educational capital for the
U.S. adult population of 5 800 US$ in 1950 and 7 200 US$ in 1957.
(Official exchange rate $1 = Nkr. 7.15).

18) Details on sources etc. and on the different educational groups are
given in Hoffmann, 1968a.

presenting some estimates on the stock of educational capital in Norway in

1950 and 1960. These are not estimates in any statistical meaningful sense,

as will be evident from the discussion above, but they may give some im-

pression of the order of magnitude. The discussion has posed many ques-

tions and probably not answered any, but the importance of investigating

more closely the production structure of the educational sector and the be-

haviour of the educational institutions and students seems evident. By

making these estimates I have sinned against the first of Bowman's, 1968,

principles of caluation of educational capital: "Measurement should be

of input flows, not of stocks". I feel, however, that there are times

when planners and decision-makers have to deal with stocks instead of

flows, as they have to allocate resources and make investment decisions in

lumps - especially in small economies - rather than on the margin.[19]

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19) Johansen & Sørsveen, 1967, have a discussion on the measurement of real
capital in relation to planning models which in parts is somewhat simi-
lar to the discussion above.

Table A.1. Educational capital in Norway at the end of 1950 and 1960
by type of education. Evaluated at replacement costs 1959/60.

Type of education	Persons			Educational capital		
	1950	1960	Change 1950-1960	1950	1960	Change 1950-1960
			Per cent	1000 mill.kr.	1000 mill.kr.	Per cent
1. General education....	.	.	.	27,7	32,6	18
a) Primary education.	2478 882	2663 081	7,4	19,6	21,1	7
b) Continuation schools etc.	231 497[1)	370 449	60,0	1,4	2,3	60
c) Secondary school- lower stage	176 363[1)	239 446	35,8	3,3	4,5	36
d) Secondary school - higher stage	93 442[1)	131 649	40,9	3,4	3,7	41
2. Vocational education.	546 738[2)	583 160[3)	6,7	9,7	12,1	25
a) Agricultural schools	48 500	52 215	7,7	0,6	0,7	8
b) Workshop schools etc.	59 031	57 518	-2,6	0,7	0,6	-7
c) Other voc. schools for industry	23 782	21 823	-9,0	0,4	0,3	-7
d) Technical schools.	22 476	37 960	68,9	0,6	1,1	93
e) Commercial schools	159 001	132 489	-20,0	1,2	1,0	-21
f) Commercial secondary schools.	29 603	34 084	-15,1	0,4	0,5	17
g) Seamen's schools..	38 543	57 117	48,2	0,7	1,0	44
h) Teachers' Training Colleges	22 911	30 795	34,4	0,8	1,0	34
i) Nursing schools etc.	21 566	32 682	51,5	0,4	0,6	53
j) Housekeeping schools	57 098	41 667	-37,0	0,2	0,2	-37
k) Other schools	32 004	41 602	30,0	0,3	0,5	46
l) Universities and colleges	32 223	43 308	34,4	3,4	4,6	34
3. Total (1 + 2)	2478 882	2663 081	7,4	37,4	44,7	20

1) Number of persons with this level as their highest education.

2) In addition 23 085 with journeymen's tests.

3) In addition 38 963 with journeymen's tests.

Table A.2. The shares of the total stock of educational capital 1950 and 1960 "due to" the different types of education.

Type of education	Persons		Educational capital		Educational capital	
	1950	1960	1950	1960	1950	1960
	Percent	Percent	Percent	Percent	Percent	Percent
1. General education	.	.	100	100	74	73
a) Primary education	.	.	71	65		
b) Continuation schools etc.	.	.	5	7		
c) Secondary school - lower stage .	.	.	12	14		
d) Secondary school - higher stage	.	.	12	14		
2. Vocational education	100	100	100	100	26	27
a) Agricultural schools	8,9	9,1	6	5		
b) Workshop schools etc.	10,8	9,9	7	5		
c) Other schools for industry	4,3	3,7	4	3		
d) Technical schools	4,2	6,5	6	9		
e) Commercial schools	29,1	22,7	12	8		
f) Commercial secondary schools ..	5,4	5,8	4	4		
g) Seamen's schools	7,0	9,8	7	8		
h) Teacher's Training Colleges ...	4,2	5,3	8	9		
i) Nursing schools etc.	3,9	5,6	4	5		
j) Housekeeping schools	10,4	7,1	3	2		
k) Other schools	5,9	7,1	3	4		
l) Universities and colleges	5,9	7,4	35	38		
3. Total (1 + 2)	.	.	.	.	100	100

Table B. Components of the costs of the educational capital, 1950 and 1960

	School costs		Income forgone		Books etc.		Total	
	1950	1960	1950	1960	1950	1960	1950	1960
	1000 mill.kr.		1000 mill.kr.		1000 mill.kr.		1000 mill.kr.	
1. General Education	$21,1^{1)}$	$23,3^{2)}$	$5,7^{3)}$	$8,1^{4)}$	1,0	1,2	27,7	32,6
2. Vocational education ..	3,7	4,8	$5,8^{5)}$	$7,1^{6)}$	0,2	0,2	9,7	12,1
3. Total	27,7	28,1	11,5	15,2	1,2	1,4	37,4	44,7
	Percent		Percent		Percent		Percent	
1. General education	76	72	20	25	4	3	100	100
2. Vocational education ..	38	40	60	58	2	2	100	100
3. Total	66	63	31	34	3	3	100	100

1) Of which: Primary education 18,8. 2) Of which: Primary education 20,2. 3) Of which: Secondary education - lower stage 2,3 and Secondary education - higher stage 2,4. 4) Of which: Secondary education - lower stage 3,1 and Secondary education - higher stage 3,4. 5) Of which: Universities 1,5. 6) Of which: Universities 2,0.

Table C. The economically active part of the educational capital, 1950 and 1960

	Persons Economically active			Educational capital Economically active			Composition of the ac.act. cap.stock	
	1950	1960	Change 1950-1960	1950	1960	Change 1950-1960	1950	1960
			Percent	1000 mill.kr.		Percent	Percent	Percent
1. General education			·	16,4	18,4	13	67	65
2. Vocational education ..	·	·	·	7,9[1]	10,1[2]	28	33	35
3. Total	1388144	1406358	1,3	24,3	28,5	18	100	100

Activity rates (percent)

1) General education ...				59	57	·		
2. Vocational education ...	·	·	·	81	83	·		
3. Total	56	53	·	65	64	·		

1) Of which: Universities: 3,1 (39 %).   2) Of which: Universities: 4,2 (41 %).

Table D. Average stock of educational capital per person by age, 1950 and 1960. 1000 kr.

Age group	General education		Vocational education		Total	
	1950	1960	1950	1960	1950	1960
15/19 years[1]	10	11	1	1	11	12
20/24 " [1] ...	13	15	3	3	16	18
25/29 " [1] ...	12	14	5	6	17	20
30/39 " [1] ...	11	13	5	6	16	19
40/49 " [1] ...	10	11	4	5	14	16
50/59 " [1] ...	10	10	4	4	14	14
60/69 " [1] ...	9	10	3	4	12	14
70 years and over[1]	9	9	2	2	11	11
All	11	12	4	5	15	17

1) For computational reasons that part of the stock of the educational capital per person which can be attributed to Continuation schools etc. are not included. In 1950 this would have been about 200 kroner in the oldest age groups and about 900 in the youngest; and somewhat more in the youngest age groups in 1960.

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