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Effect of School on Interest in Natural Sciences: A comparison of the Czech Republic, Germany, Finland and Norway based on PISA 2006

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3 **Effect of School on Interest in Natural Sciences: A comparison of the Czech Republic,**
4 **Germany, Finland and Norway based on PISA 2006**
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7 **Abstract**
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9 The theme of this paper is student interest in future natural sciences–related careers. It is
10 based on data from the Programme for International Student Assessment (PISA) survey that in
11 2006 focused attention on the science literacy achievements of students. The paper uses the
12 methods of linear regression modelling and structural equation modelling in analysing the
13 impact of student family background on the formation of interest in future science-related
14 educational and occupational careers relative to the impact of school characteristics. An almost
15 negligible impact of family on interest formation was found in the Czech Republic, Germany,
16 Finland and Norway. On the other hand, the impact of school from the point of view of
17 preparing students for future educational and career trajectories was found to be strong in all
18 countries studied due to their influence on the degree of student awareness of science-related
19 career opportunities ('science', as used in this paper, refers to the natural sciences). From the
20 educational policy point of view, the results support the importance of career guidance.
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3 Despite the need to understand an ever-broader spectrum of themes in the area of natural
4 and technical sciences in today's world, the Organisation for Economic Co-operation and
5 Development (OECD, 2007) has reported that the Czech Republic has seen a decreasing
6 proportion of university students majoring in technical and science subjects (Palečková, 2007).
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8 This is a trend that is present in most developed countries, as shown by international studies
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10 (Eurydice, 2006; OECD, 2007).
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17 In the context of an assumption that individual countries cannot prosper unless they
18 support education and training to produce top experts in science and technical subjects, we can
19 still observe differences among countries in student proportions by university subject. For
20 example, in Czech Republic universities, 12% of students take medical subjects and 15% take
21 technical subjects; in Germany it is 16% and 15% and in Finland 18% and 25% (OECD,
22 2009c).
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31 In the Czech Republic, interest in studying technical and science subjects at universities
32 has been relatively low in the past decade. This is evident in the proportion of students trying to
33 achieve admission to various subject areas. For the past 10 years, demand has been much higher
34 in the case of law studies (with admission success rates fluctuating between 20% and 30%)
35 compared with natural science and technical science subjects (with the success rate fluctuating
36 around 60 to 70 %; Institute for Information on Education (IIE), 2008a, 2008b). In other words,
37 natural sciences have not been in style over the last 10 years in the Czech Republic. This is one
38 of the reasons why, in this paper, we try to identify the potential causes of the relatively low
39 interest among 15-year-old students in further science-related education and careers.
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53 At the same time, demand in the labour market has shown the complete opposite trend.
54 Although graduates of natural sciences have higher average incomes than graduates of the
55 humanities or social sciences, employers have been pointing out a shortage of qualified
56 graduates. Unfortunately, the fields of natural sciences and engineering are perceived as 'too
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3 difficult' by many young people. The Czech ministry of education wants to change this image:
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6 In 2009, it started a project focused on preparation and launched a publicity drive.
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8 **Research Background**

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10 Generally, there are several reasons for countries and governments to support the
11 creation of a positive relationship with science in young people. The endeavour to strengthen
12 the science expert base should be one of the key aspects of this trend (OECD, 2007). With a
13 positive relationship to science, there is a higher probability of students being motivated to
14 choose science-related further education or careers than would be the case otherwise. Baram-
15 Tsabari and Yarden (2009) have found that interest in science influences educational and career
16 choices. To a degree, interest in science also correlates positively with science literacy scores
17 when the so-called top performers are concerned (OECD, 2009a, p. 12). Apart from this, a
18 report on the outcomes of the Programme for International Student Assessment (PISA) study of
19 2006 discusses the great potential of schools to support student interest in science by providing
20 information on science-related career opportunities (OECD, 2007). In many countries, there is a
21 correlation between the relationship to science and student socioeconomic background (OECD,
22 2007).
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41 Apart from the effect of family background (OECD, 2007), the effects of school climate
42 and instructional processes are also taken into account. Simpson and Oliver (1990) point out
43 that science education at the elementary school level, where there is a focus on the instructional
44 aspect, significantly influences interest in science. Further, according to Mistler-Jackson and
45 Songer (2000), the perception of a positive learning environment has a strong potential in
46 fostering science motivation and achievement.
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55 As stated above, interest in science from the viewpoint of anticipated future career has a
56 positive correlation to the results achieved in science literacy testing. Although the Czech
57 Republic's PISA 2006 science literacy results were above the OECD average (Palečková,
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3 2007), the latest findings of the Trends in International Mathematics and Science Study
4 (TIMSS) 2007 international survey raises concerns in regard to decreasing interest in science
5 and technical subjects. In this international comparison, Czech students achieved above average
6 science results in both the fourth and eighth grades (Martin, Mullis, & Foy, 2008), but the
7 mathematics results were below average for the fourth grade and average for the eighth grade
8 (Mullis, Martin, & Foy, 2008). The decline of Czech students' average achievement over time
9 is particularly alarming. Whereas in 1995 Czech students' average scores were significantly
10 higher than the international average in both the areas monitored (mathematics, science), in
11 2007, only students in science maintained this position (Tomášek, 2008). In the case of the
12 Czech Republic, this was one of the most significant average score decreases when compared to
13 other European or OECD countries.
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29 **Data and Methods**

30 **Focus of Analyses and Data Used**

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34 The analyses presented in this text were performed on the dataset of the PISA 2006
35 international survey. The PISA survey focuses on testing the science, mathematics and reading
36 literacy of 15-year-old students. The survey has been conducted since 2000 in three-year cycles,
37 each time focusing on one of the subject domains in more depth than the other two. In 2006,
38 science was the major domain.
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46 We used the methods of correlation analysis, linear regression modelling and structural
47 equation modelling to analyse the data. All analyses pertain to the individual student level.
48 Analyses were conducted using the SPSS software package. To weight the cases, the variable
49 'final student weight' was used. To treat missing values, 'pairwise exclusion' was used.
50 Plausible values were not a part of the analyses.
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58 **Research hypotheses.** The research hypotheses defined below are based on several
59 assumptions discussed in the research background section. In terms of interest in future science-
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3 related education and career, we consider the impact of parents and schools as two important
4 factors. In relation to the presupposed endeavour of states to educate experts in science, we
5 focus primarily on students who attained the best science literacy test scores.
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10 The analyses performed are based on the following hypotheses, formulated using the
11 above assumptions:
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14 1. The impact of family background and the impact of school on student interest in
15 future science-related education and careers are equally strong.
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- 18 2. There is a positive relationship between the level of parental educational attainment
19 and occupational status and student interest in future science-related education and
20 careers.
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- 23 3. Students achieving the best science literacy test scores display higher interest in
24 future science-related education and careers than students achieving at lower levels.
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- 27 4. Girls display lower interest in future science-related education and careers than boys.
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34 **Countries considered.** The PISA 2006 science literacy achievements are expressed
35 using scores or proficiency levels. There are six proficiency levels, and levels 5 and 6
36 correspond to the best scores. Students achieving these levels are referred to as high achievers
37 or top performers (OECD, 2009a, 2009c). The proportions of high achievers from individual
38 countries correspond to the proportion of students who have mastered the science competences
39 and knowledge very well, and therefore have good prerequisites to excel in science in the future
40 and to contribute to an increase in their country's potential (Palečková, 2007).
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51 In the framework of the analyses, the situation in the Czech Republic is compared to
52 three other countries in order to embed it in an international context. Given the analytical focus
53 on high achievers (proficiency levels 5 and 6), the countries for comparison were selected
54 according to this criterion.
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3 The following countries were selected for comparison with the Czech Republic's
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5 situation:
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- 8 1. Germany: The proportion of high-achievers is similar to the Czech Republic.
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- 10 2. Finland: The proportion of high-achievers is higher than in the Czech Republic.
- 11
- 12 3. Norway: The proportion of high-achievers is lower than in the Czech Republic.
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15 Table 1 illustrates the distribution of the proportions of students achieving the two
16
17 highest proficiency levels in the countries considered.
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22 [Insert table 1 about here]
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24 25 26 **Analyses** 27

28 For the purposes of the analyses presented here, interest in science-related careers as a
29
30 dependent variable (study and occupation considered) is expressed by the four variables
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32 included in question 29 of the student questionnaire. All of these variables are covered by the
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34 index future-oriented science motivation (SCIEFUT; for details see Table 2)¹. All of the items
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36 used were reverse scored so that positive index scores represent higher levels of motivation
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38 (OECD, 2009b).
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45 [Insert table 2 about here]
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49 50 **Linear Regression Modelling** 51

52 For the regression model dealing with the situation in the Czech Republic (for variables
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54 see Table 2), the forward stepwise method was applied. On that basis, we can state that the most
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56 important influence on student interest in science-related future education and careers (Table 3)
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58 is the level of awareness of science-related career opportunities (variable CARINFO). The
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¹ The variables were created by the PISA Consortium and are part of the PISA 2006 international dataset (OECD, 2009b).

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3 variable explains almost 15% of the variance in the dependent variable. The second most
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5 important explanatory variable was found to be the CARPREP variable (how school prepares
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7 students for future education and career), explaining the level to which the school prepares
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9 students for future education and careers. Third is the variable expressing whether the student
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11 belongs in the highest scoring student group from the point of view of science literacy (variable
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13 PL_high). The model shows that science literacy test scores increase with interest in science-
14
15 related careers. Next, we controlled for the students' gender and family background (highest
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17 attained parent education and highest parent occupational status).
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22 [Insert table 3 about here]
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27 In total, the model (Table 3) explains almost 20% of the dependent variable variance,
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29 which indicates moderate explanatory power. It is possible to say, however, that the variables
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31 HISEI (highest attained parent occupational status) and HISCED (highest educational
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33 attainment of parents), related to student family background, do not have an important influence
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35 on explained variance. In the case of the highest parent occupational status, we even observe a
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37 negative impact on the explained variable (Table 3).
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41 The same model was used to compare the results of the Czech Republic with Germany,
42
43 Finland and Norway. The model containing all variables mentioned explains almost 20%
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45 dependent variable variance (19.8%) in the case of Germany and the same applies for Finland
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47 (19.4%). The model for Norway does not contain the HISEI variable because it was not
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49 statistically significant. The resulting model explains 17.2% of the dependent variable variance.
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53 As was the case with the Czech Republic, variables representing family background do
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55 not explain much of the extra dependent variable variance in any of the compared states. In
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57 each of the three compared states, the most important influence was found in the awareness
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59 level of the science-related career opportunities (variable CARINFO). This is consistent with
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3 the Czech Republic. However, unlike the Czech Republic, for Germany, Finland and Norway
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5 (Table 4), the second most important influence was found for variable PL_high, the variable
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7 indicating whether or not the student belonged to the group with the highest science literacy test
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9 scores.
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16 [Insert table 4 about here]
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21 The variable CARPREP, indicating the degree to which the school prepares students for
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23 their future education and career, takes third position in explanatory power for the dependent
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25 variable in all three compared countries. The three variables mentioned above, in combination,
26
27 explain 18.9% of the dependent variable variance for Germany, 18.7% for Finland and 16.7%
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29 for Norway. As in the Czech Republic's case, other variables accounted for in the model bring
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31 significantly lower explanatory power for the dependent variable.
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35 Other differences can be observed as to students' gender, which is controlled for in the
36
37 model. In the Czech Republic and Finland, higher interest in future science-related careers can
38
39 be seen in girls, while higher interest was found in boys in the cases of Germany and Norway.
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43 44 **Structural Equation Modelling**

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46 The issues were also examined using the method of structural equation modelling.
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48 Following the research question and hypotheses, a diagram was created depicting the causal
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50 model of analysed relations. A structural equation modelling method using the AMOS software
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52 was chosen.
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56 [Insert figure 1 about here]
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3 Following the hypotheses and the causal model (Figure 1), a structural model was
4 derived of family background impact on the interest in future science-related careers. The
5 model defines a latent variable indicating student family background (FamB) measured by the
6 highest attained parent education (HISCED) and highest attained parent occupational status
7 (HISEI). The latent variable indicating student interest in future science-related career
8 (SCIEFUT) is measured by four variables (indicating responses to the following four
9 statements: I would like to study science after secondary school; I would like to work in a
10 career involving science; I would like to spend my life doing advanced science; I would like to
11 work on science projects as an adult).

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25 The third latent variable, indicating student awareness of science-related career
26 opportunities (CARINFO), is measured using four variables (for the wording of the questions
27 see Table 2). The last latent variable, representing how the school prepares students for their
28 future educational and career trajectory (CARPREP), is also measured using four variables (for
29 the wording of these questions see Table 2). To keep the model simple, gender of students was
30 not considered, as we tried to focus mainly on the influences of school and family background.

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Based on the structural analysis results (Figure 2), it can be concluded that in the Czech Republic, there is no significant impact of family background on student interest in future science-related careers. Moreover, direct family background impact on interest (SCIEFUT) was not statistically significant (Table 5). Structural equation modelling confirmed the finding reached in regression modelling, i.e. that student interest in future science-related careers is significantly influenced by school and in particular by the degree to which the school prepares students for their future education and careers.

It needs to be noted that there are also some limitations to the analyses. PISA does not provide direct and objective measures, as items included in the variables CARPREP and CARINFO are self-reports expressed by students. Next, the cross-sectional arrangement of the data does not allow us to see which students actually did pursue a science-oriented educational pathway. We only can work with their plans and aspirations.

Discussion and Conclusions

Some authors point out that it is more accurate to monitor interest in science for each science subject separately (Prokop, Tuncer, & Chudá, 2007). However, the data used for our analyses does not allow this. We do not consider this to be a serious shortcoming of our research conclusions because the issue of (dis)interest in science is often discussed on a more general level without distinguishing individual sub-areas. Moreover, it needs to be taken into account that in many countries, science is taught as an integrated subject, not as individual subjects.

Impact of family background on future science-related study and/or career has not been demonstrated by our analyses. Our findings, nevertheless, show a fairly strong influence of school in this respect. We have found that the interest in future careers is significantly

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3 influenced by the degree to which the school prepares students for future education and careers.
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5 The school, then, also influences a more general indicator--the level of awareness of science-
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7 related career opportunities, which is also crucial for interest.
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10 This finding seems to be important, at least in the context of the Czech Republic, from
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12 the point of view of educational policy. In this respect, the results of our analysis support
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14 activities that are usually referred to as career counselling or guidance. In the Czech Republic,
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16 this is an area which has begun to develop and be supported only in the last five years. It is also
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18 obvious from the international comparison that the role of school in the formation of interest in
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20 future science-related careers is irreplaceable.
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24 Although our findings are rather surprising, as some significant influence of parents on
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26 interest in future science-related careers was expected, the fact that the effect of school was
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28 found to be much more important is good in relation to possible policy provisions. In general,
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30 the influence that a school may have on students and activities that schools can develop are both
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32 seen as more effective indicators of future science career aspirations than the occupational
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34 status and education levels of parents.
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38 As far as possible future research is concerned, we think that there should be a focus on
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40 the best-performing students in science literacy and analysis of whether they later on actually
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42 choose a science-related educational and professional career or not. A study using a
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44 longitudinal survey arrangement would be suitable for this purpose.
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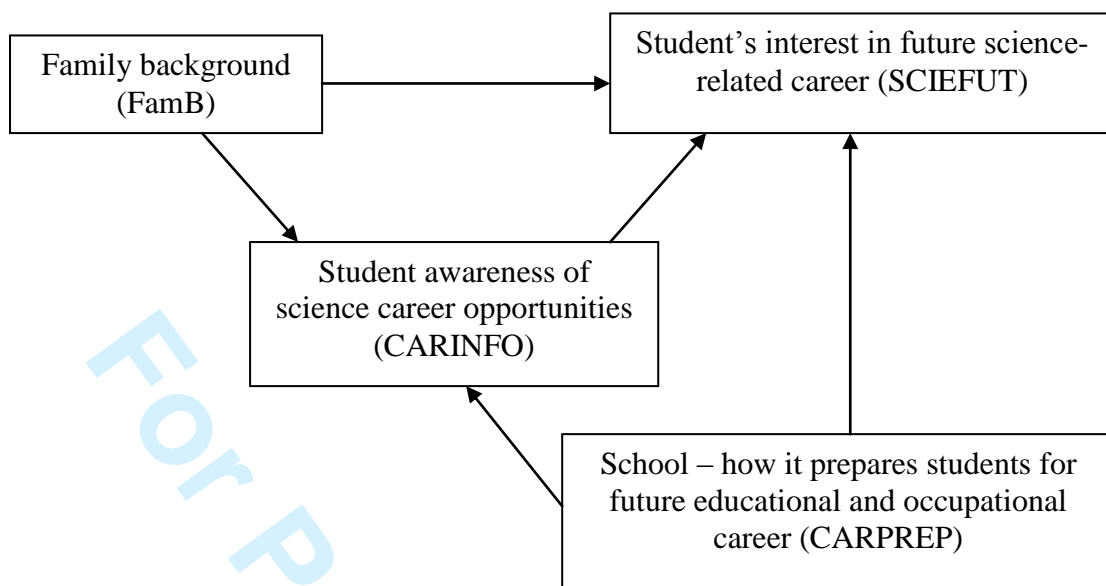
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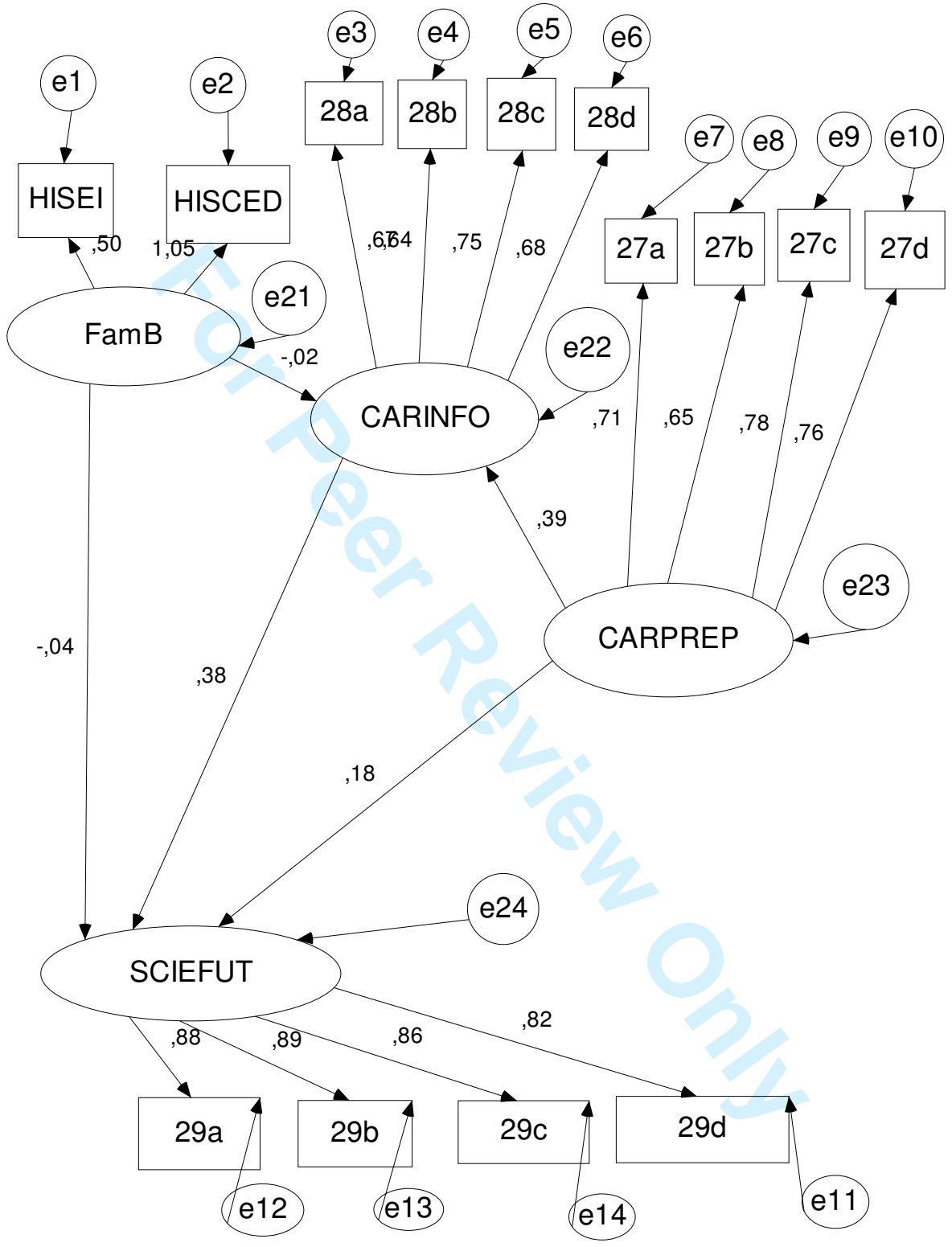
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Chi-square=1057,1 df=72 p=0.000 GFI=0.974

Table 1.

Proportion of Students who Achieved the Two Highest Proficiency Levels (Selected Countries)

Country	Mean score	S.E.	% at proficiency level 5	S.E.	% at proficiency level 6	S.E.
Czech Republic	513	3.5	9.8	0.9	1.8	0.3
Finland	563	2.0	17.0	0.7	3.9	0.3
Germany	516	3.8	10.0	0.6	1.8	0.2
Norway	487	3.1	5.5	0.4	0.6	0.1
OECD average	500	0.5	7.7	0.1	1.3	0.0

Source: PISA 2006.

Table 2.

Variables Used for Regression Modelling

Type	Variable label	What it measures	Values	Items
Dependent	SCIEFUT	Interest in future science-related education and careers (student)	Standardised index (range from -1.42 to 2.27)	I would like to study science after secondary school; I would like to work in a career involving science, I would like to spend my life doing advanced science; I would like to work on science projects as an adult (all of these have response categories: strongly agree, agree, disagree, strongly disagree).
Independent	HISEI	Highest parent occupational status	Values from 16 to 90	
	HEDRES	Highest parent education attainment	Standard ISCED categories	
	Gender	Gender of student	0=male, 1=female	
	PL_high	If student achieved proficiency level 5 or 6 in the science literacy test	0=no, 1=yes	
	CARINFO	Level of awareness of science-related career opportunities	Standardised index (range from -2.43 to 2.53)	(a) <Science-related careers> that are available in the job market (b) Where to find information about <science-related careers> (c) The steps a student needs to take if they want a <science-related career> (d) Employers or companies that hire people to work in <science-related careers> Item categories were 'Very well informed', 'Fairly informed', 'Not well informed' and 'Not informed at all'; all items were inverted for scaling.
CARPREP	Level to which the school prepares students for future education and career	Standardised index (range from -2.92 to 1.95)	(a) The subjects available at my school provide students with the basic skills and knowledge for a <science-related career> (b) The <school science> subjects at my school provide students with the	

				<p>basic skills and knowledge for many different careers</p> <p>(c) The subjects I study provide me with the basic skills and knowledge for a <science-related career></p> <p>(d) My teachers equip me with the basic skills and knowledge I need for a <science-related career></p> <p>Item categories were 'strongly agree', 'agree', 'disagree' and 'strongly disagree'; all items were inverted for scaling.</p>
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Table 3.

Regression Model for the Czech Republic (PISA 2006)

	Unstandardized Coefficients		R Square (cumulative)	Standardized Coefficients		t	Sig.	Collinearity Statistics	
	B	Std. Error		Beta	Tolerance			VIF	B
(Constant) SCIEFUT	-0.175	0.010			-17.138	0.000			
Student information on science-related careers (CARINFO)	0.297	0.003	0.148	0.324	118.205	0.000	0.897	1.115	
School preparation for science-related careers (CARPREP)	0.159	0.003	0.179	0.166	60.138	0.000	0.881	1.135	
PL 5 and 6 (PL_high)	0.283	0.008	0.189	0.102	37.232	0.000	0.901	1.109	
Gender	0.155	0.005	0.196	0.087	33.414	0.000	0.986	1.014	
Highest educational level of parents (HISCED)	0.030	0.002	0.196	0.040	13.047	0.000	0.707	1.415	
Highest parental occupational status (HISEI)	-0.002	0.000	0.197	-0.038	-12.093	0.000	0.694	1.440	

a. Dependent Variable: Future-oriented science motivation

Table 4.

Regression Model for Germany, Finland, Norway (PISA 2006)

	Germany				Finland				Norway			
	Unst. Coeff.		R Square (cumul.)	Stand. Coeff.	Unst. Coeff.		R Square (cumul.)	Stand. Coeff.	Unst. Coeff.		R Square (cumul.)	Stand. Coeff.
	B	Std. Error			B	Std. Error			B	Std. Error		
(Constant) SCIEFUT	-0.398	0.004			-0.651	0.015			-0.401	0.020		
Student information on science-related careers (CARINFO)	0.346	0.001	0.142	0.318	0.295	0.004	0.106	0.288	0.277	0.004	0.128	0.295
PL 5 and 6 (PL_high)	0.524	0.003	0.177	0.161	0.546	0.008	0.182	0.255	0.640	0.017	0.154	0.145
School preparation for science-related careers (CARPREP)	0.108	0.001	0.189	0.116	0.067	0.004	0.187	0.067	0.123	0.004	0.167	0.124
Gender	-0.145	0.002	0.194	-0.071	0.076	0.006	0.191	0.044	-0.076	0.008	0.170	-0.039
Highest educational level of parents (HISCED)	0.030	0.001	0.197	0.045	0.033	0.003	0.193	0.046	0.052	0.004	0.172	0.053
Highest parental occupational status (HISEI)	0.002	0.000	0.198	0.037	0.002	0.000	0.194	0.046	not sig.			

Table 5.

Overview of Standardised Effects and Their Significance (CR, PISA 2006)

	Estimate	S.E.	C.R.	P
CARINFO <--- FamB	-0.001	0.001	-1.147	0.252
CARINFO <--- CARPREP	0.430	0.019	22.484	***
SCIEFUT <--- CARINFO	0.530	0.024	22.520	***
SCIEFUT <--- CARPREP	0.281	0.024	11.834	***
SCIEFUT <--- FamB	-0.004	0.001	-3.404	***
HISEI <--- FamB	1.000			
HISCED <--- FamB	0.177	0.085	2.074	0.038

*** significant at 0.01 level