The Bebras Contest in Austria – Do Personality, Self-Concept and General Interests play an Influential Role?

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Abstract. The Bebras (Beaver) contest aims at testing of and motivating for Informatics and Computer fluency, and as such it is designed to be a contest for all pupils between 8 and 19. But, does it really attract and favor all types of children likewise? This paper takes a closer look at different types of personality, self-concept and interests of the winners of the Bebras contest in Austria and discusses those factors that might contribute to a successful participation. It concludes with some recommendations that might help in increasing the number of participation at the event.

Keywords: Bebras Contest · Personality · Self-Concept.

1 Motivation

It is a big challenge for society to foster interest in computing as a 21st century skill among children and adolescents. A single definition on what should be taught at school is hard to give, and this is the responsibility of the respective ministries of each country. However, in the future, the need on skilled workforce to meet the requirements of the industry 4.0 will increase. Thus, it gets more and more important for the education sector to honor this evolution. There are already initiatives on different levels in place to foster competences and interests in informatics, e.g. from ministries or other organizations up to private groups like CoderDojo (more examples were shown by Grandl and Ebner [9]). In the field of informatics, the Bebras (Beaver) Contest (described by Dagienė and Futschek [7]) has a competitive character to motivate pupils of different ages with the aim to make them familiar with informatics concepts and computational thinking. On the one hand it fosters basic skills in informatics, but it also can, and according to the key driver behind the contest it also should, attract all different types of pupils for this field of science.

Participants have to be nominated by schools and cannot register individually. There are both advantages and disadvantages to this approach. Pupils that

did not consider participating might get in touch with informatics and their interest may be aroused, but on the other hand interested individuals rely on the willingness of their school to be part of this competition. This causes a broad range of levels of interest, from high to low attentiveness. But, very little is known about the personalities and structure of interests of the participants, especially the differences between winners and unsuccessful contestants. Relevance to gain greater knowledge on this issues is obvious, having the requirements of the 21st century in mind. Tailor-made offers to attract children and adolescents to informatics can help to avoid skills shortage in this field. To obtain satisfactory effects, it is important to intervene at an early age.

For this reason, the objective of this paper is to take a closer look at the different types of personality, the self-concept and the interests of the winners of the Bebras contest in Austria and to discusses those factors that might contribute to a successful participation. The results are additionally compared to two other populations: two school classes who participated at the Bebras Contest without winning, and a set of teenagers who successfully took part at an international (and quite demanding) coding contest – as we also wanted to check for pronounced differences.

The rest of the paper is structured as follows: Section 2 provides background information about related work and summarizes the tests used during our study. Section 3 presents the details of the study, introduces the hypotheses and summarizes the results. Section 4 then reflects on the findings and Section 5 concludes with a summary and an outlook.

2 Background

2.1 Testing the Masses

Contests for testing students in their abilities in certain subjects and topics have been developed and implemented in many countries. However, the number of studies looking at criteria, ability and skills determining whether someone is among successful students is very low.

In the field of informatics and computational thinking, the probably widest-known contest is the Bebras Contest [7]. In the meantime, Bebras turned into a diverse event, where individuals or teams are competing to each other at various settings and levels of difficulty. The tasks in the Bebras Contest are developed considering a set of criteria (some have to be and some should be fulfilled by all tasks), e.g. 'Good tasks are related to informatics, computer science or computer literacy'. The criteria provide general information about the development of the tasks (topics, representation of the tasks, no previous knowledge required). Some of the criteria consider the abilities of the students: The tasks 'have a difficulty level (3 levels)', 'are adequate for the age of the contestants (3 age groups)' and 'are independent from any curriculum'. The difficulty levels have a range from 'all pupils of the target group should be able to solve' to 'only the best can solve these tasks'. A revision to these criteria was stated in 2014 by Vaníček [16]. Amongst

others, the acceptance of tasks that require no(!) pre-knowledge is recommended. A rich and still ongoing discussion about good tasks can be found on the web-site of the Bebras contest [4].

A comparable contest in the field of mathematics is the International Mathematical Kangaroo [2]. A study by Applebaum looking at the results of the Mathematical Kangaroo showed that the achievements of mathematically motivated students in tasks that require spatial abilities correlate with their achievements in non-standard problems [3]. This study links a cognitive skill, the spatial ability, with the achievements in mathematics of this student.

The perception of learning activities is an issue for different studies. Theodoropoulos et al. performed a study in Greek schools to assess the relationship of certain students' personality structures (the cognitive styles) and the students' attitude (the students' quality of learning experience) towards the game-based programming activities of *code.org*. The study shows that specific cognitive styles differed by the Myers-Briggs Type Indicator (MBTI) correlate with higher achievements in the provided tasks. Therefore a more balanced and personalized approach is recommended [15].

2.2 Personality, Self-Concept and General Interests

Psychological theories, like the theory of work adjustment by Dawis [8] and the RIASEC theory of careers by Holland [10] assume, that individual needs and skills become relative stable between the age 14 and 24 (as shown by Nerdinger et al. [13]). Individual needs is a generic term and includes motives, personality, interests and social values, which are essential for successful professional careers. Influencing variables on the career choice are vocational interests, intelligence and personality (shown by Ackermann and Beier [1]). Career choice is a conscious decision; people try to find a job with the highest match between personality structure and the job profile (person-job-fit). When there is a good fit between the personality type and environmental requirements, people are much more satisfied and successful in their jobs [10]. Holland formulates six interest dimensions: Realistic (R), Investigative (I), Artistic (A), Social (S), Enterprising (E), and Conventional (C). The dimensions are presented hexagonal in the order of RIASEC. Dimensions of interests are more similar to each other, the closer they are presented at the Hexagon. Example giving, Realistic and Investigative have much more in common, than Realistic and Social. Bergmann and Eder presented a list to identify fields of study or careers consistent with the individual interest dimensions [5]. Each profession is assigned a three-letter code. Informatics and information management is allocated to the code CIS (Conventional, Investigative and Social). There are some code variations depending on the vocational specifications, e.g. ICE for business informatics. The dimensions Conventional and Investigative seem very important for a good fit to the field of informatics.

Interests play an important role in the career finding process and far beyond in the success and satisfaction within the job. So the question is, how to

foster these interests in an early stage. Building up opportunities for the mainstream to get in touch with concepts of informatics and computational thinking – like the Bebras – is a practicable way. Such experiences may foster a positive subject-specific self-concept. The self-concept gives an assessment about individual strength and weaknesses. A positive self-concept has an influence on the learning process. It influences the decision, which learning objectives and tasks pupils set. Results from PISA demonstrate a positive correlation between self-concept and results [14]. The development of the self-concept is affected from self-observation and feedback, e.g. from teachers or success in competitions. A positive self-concept will be built up by experience.

3 The Study

3.1 Setting

In order to assess influences of personality, academic self-concept and general interest on Bebras participation, a survey was employed to collect these factors from different groups. The survey was conducted in paper form as well as in the online environment KAUA[1], and contains the following data fields:

Demographic data: Sex (male / female / other), age

General interests: Six Likert items for the six dimensions of interests (RIASEC) following Holland [10]. Two variants of formulations are used, depending on the age of the participants. Survey participants older than 14 receive the standard formulation (scale with 9 items) of the general interests test [5]; others receive a re-formulation for children (scale with 3 items). The results per dimension are grouped in three equally sized brackets: not interested, partly interested, very interested.

Personality: Two Likert items (scale with 13 items) for two dimensions (Dominant / Easy-Going, Formal / Informal) of the Five-Factor and Stress Theory [12, 17]. Two variants of formulations are used, depending on the age of the participants. Survey participants older than 14 receive the standard formulation; others receive a re-formulation for children.

Academic self-concept: A set of questions for verbal as well as mathematical self-concept is surveyed. Each consists of three statements[2] regarding the respective self-concept, on a scale with 4 items between disagreement and agreement, which are also included in PISA surveys [11]. Moreover, for both German (the medium of instruction in Austria) and Mathematics, the last received school grades and the self-given grades are surveyed (*VGrade*, verbal, and *MGrade*, mathematical).

[1] KAUA is an online survey system with support for anonymous, longitudinal studies, designed for and implemented at the Department of Informatics Didactics, Alpen-Adria-Universitt Klagenfurt.

[2] V_1: I am hopeless in German classes. V_2: I learn things quickly in German classes. V_3: I get good marks in German. M_1: I get good marks in mathematics. M_2: Mathematics is one of my best subjects. M_3: I have always done well in mathematics.

The data was collected for three groups to compare the different factors:

Bebras winner group: 43 Austrian Bebras winners (20 males, 23 females, mean age 11.57±2.13) were surveyed in paper form during the Bebras 2018 award ceremonies.

Bebras control group: 36 non-winning Austrian Bebras participants (12 males, 21 females, 3 others, mean age 12.08±0.84) were surveyed in online form to provide a means of comparing winner and non-winner participants.

School Coding-contest group: 20 male participants of the Catalysts School Coding Contest[3] 2018 in Klagenfurt (mean age 17.80±0.62) were surveyed in online form to provide another control group of computer science interested students.

Two sets of hypotheses are evaluated for the collected data:

H1-H2: Bebras winners statistically differ significantly in personality, academic self-concept and general interests from the control group (H1) and the coding-contest group (H2).

H3-H5: Factors of personality (H3), academic self-concept (H4) and general interests (H5) contribute to winning the Bebras contest in Austria.

Hypotheses H1-H2 are evaluated with the help of U-test statistics, and analysis of correlations and plots. Hypotheses H3-H5 are evaluated with the help of mean value comparisons, t-test statistics, correlation analysis and linear regression.

Table 1. Mean values for: Six dimensions of interest (range $[-1, 1]$, from *not interested* to *very interested*), two personality dimensions (range $[-6, 6]$), agreement to six statements of academic self concept (V_i and M_i, range $[1, 4]$ from *disagreement* to *agreement*), actual and self-given grades in the subjects German and Mathematics (*VGrade*/*MGrade*, range $[1, 5]$).

Group	R	I	A	S	E	C	Easy-Going	Informal
Winner $_1$	0.26	0.64	$_3$ 0.45	$_3$ 0.56	0.39	0.12	$_2$ 1.791	0.002
Control $_2$	0.27	0.39	0.22	$_3$ 0.61	0.39	0.11	$_{1,3}$ -1.500	-0.417
School-CCC $_3$	0.33	0.68	$_1$ -0.13	$_{1,2}$ 0.19	0.29	0.15	$_2$ 0.800	-0.250

Group	V_1	V_2	V_3	VGrade Actual / Self	M_1	M_2	M_3	MGrade Actual / Self
Winner $_1$	1.71	$_2$ 3.14	3.21	1.88 / 1.74	$_2$ 3.58	$_2$ 3.31	$_2$ 3.41	1.72 / 1.57
Control $_2$	1.94	$_1$ 2.75	2.81	2.39 / 1.94	$_1$ 3.19	$_1$ 2.75	$_1$ 2.94	2.08 / 1.81
School-CCC $_3$	1.60	2.90	3.15	2.10 / 2.00	3.55	3.25	3.15	1.75 / 1.65

[3] More information: https://register.codingcontest.org/

3.2 Results

This section contains descriptive result tables summarizing the data, and tables and plots of additional analysis. The results are discussed in the next section.

Table 1 shows a summary of the data for the three surveyed groups of students. Mean values for the different dimensions of data are reported. Questions regarding the areas of interest are answered on a scale of three items (winner and control group) or nine items (School-CCC group) ranging from *not interested* to *very interested*, and are encoded numerically in the range [-1, 1]. The middle interpretation *partly interested* is encoded as 0 on the coarse scale and in the range [-0.25, 0.25] in the more fine-grained scale. Negative values of personality indicate the first personality types (Dominant and Formal), positive values indicate the second personality types (Easy-Going and Informal). For brevity, only the positive ones are written. The questions regarding the academic self-concept (V_i and M_i) are answered on a scale of four items ranging from disagreement to agreement, encoded from 1 to 4. Low values indicate a weak self-concept, high values indicate a strong self-concept. This is true for all items but V_1, which is an inverse item. Furthermore, the students were asked to report their last received grades and the grades they would give themselves in the subjects German and Mathematics, encoded from 1 to 5; lower numbers indicate better grades.

Table 1 also shows significant differences between groups. Shapiro-Wilk tests with significance level $p < .05$ were used to test for the null hypothesis of normal distribution. For most of the data columns, the null hypothesis could not be rejected. Therefore, significant differences were found employing non-parametric Mann-Whitney-U-Tests with significance level $p < .05$. Significant differences are marked with subscript row numbers signifying the relationships (1 for differences to the winner group, 2 for differences to the control group, 3 for differences to the School-CCC group), and are marked symmetrically.

Table 2 shows statistical analysis results employed on the combined groups of all Bebras participants (winner+control). A binary variable *winner* with value 0 for non-winners and 1 for winners was introduced. For this variable, all significant correlation scores are reported in the table (significance level $p < .05$, linear and rank correlation was examined, Kendall results are omitted as they are the same as Spearman results). Moreover, a linear regression model was fitted for the response variable *winner*, with iterative backward selection and significance level $p < .05$. The table reports all significant variables with their estimated prediction factors, and reports the regression scores measured as multiple and adjusted R^2. *SexM* and the not significant *SexF* are binary auxiliary variables introduced with value 1 for participants of the respective sex and 0 for others. The Spearman correlation scores between the significant factors of linear regression are also reported for the winner and control group.

Figure 1 shows the distribution of the surveyed students in a plane with the personality dimensions Dominant/Easy-Going and Formal/Informal. Each point corresponds to one student, distinct points may overlap. For each group, the mean personality values are included in the plane, together with a circle representing the 33% percentile of data points nearest to the mean for the resp. group.

Table 2. Statistical analysis of binary variable *winner*, computed for both Bebras groups ($n = 79$). Factors and correlations significant at $p < .05$ are marked bold. Results show significant correlation scores for the variable *winner*, linear regression model fitted with iterative backward selection for the response variable *winner*, and spearman correlation scores between regression factors.

Correlations for *winner*

Correlation	Easy-Going	V_2	VGrade Actual	M_1	M_2	M_3
Pearson	**0.46**	**0.23**	**-0.22**	**0.24**	**0.26**	**0.25**
Spearman	**0.46**	**0.23**	-0.20	**0.23**	**0.29**	**0.25**

Linear Regression for *winner*

Feature	Intercept	SexM	Artistic	Social	Easy-Going	M_3
Estimated Factor	-0.147	**0.529**	**0.217**	**-0.161**	**0.089**	**0.147**
Multiple R^2	0.4909		Adjusted R^2	0.4560		

Spearman Correlations for Regression Factors
Top half winner ($n = 43$), bottom half control ($n = 36$)

Control \Winner	SexM	Artistic	Social	Easy-Going	M_3	
SexM	1	**-0.57**	**-0.49**	**-0.53**	0.16	
Artistic	**-0.74**	1	**0.51**	0.20	**-0.32**	
Social	-0.16	0.27	1	**0.56**	0.05	
Easy-Going	**-0.72**	**0.54**	0.10	1	-0.04	
M_3	0.18	0.16	0.05	**-0.42**	1	

Figure 2 show scatter plots between the variable *winner* and four of the significant factors of correlation and linear regression analysis shown in Table 2. Figure 3 shows the distribution of the responses for each area of interest for the winner and control groups. For the students, it is possible to choose the same level of interest for multiple areas.

3.3 Discussion

Concerning **interests**, differences were uncovered between the groups. According to the RIASEC test (see Table 1 and Figure 3), Bebras winners are more investigative (mean 0.64 compared to 0.39) and more artistic (mean 0.45 compared to 0.22) than the control group. The result is not statistical significant, but Figure 3 also shows that winners are, with the exception of the social dimension, in general more interested in all the other fields of interest. Bebras winners (and coding contest participants) seem to be more curious and open to explore new things. It is notable that the School-CCC participants are less interested in the social dimension (the smaller number-labels in Table 1 indicate that this observation is also statistical significant to the winner and control group).

In some sense this tells us that Bebras participants are quite comparable to the control group, they just show a bit higher interest in everything and are more interested in the artistic field. The type of Bebras questions (which are quite often very creative and try to be out of different domains) seems to

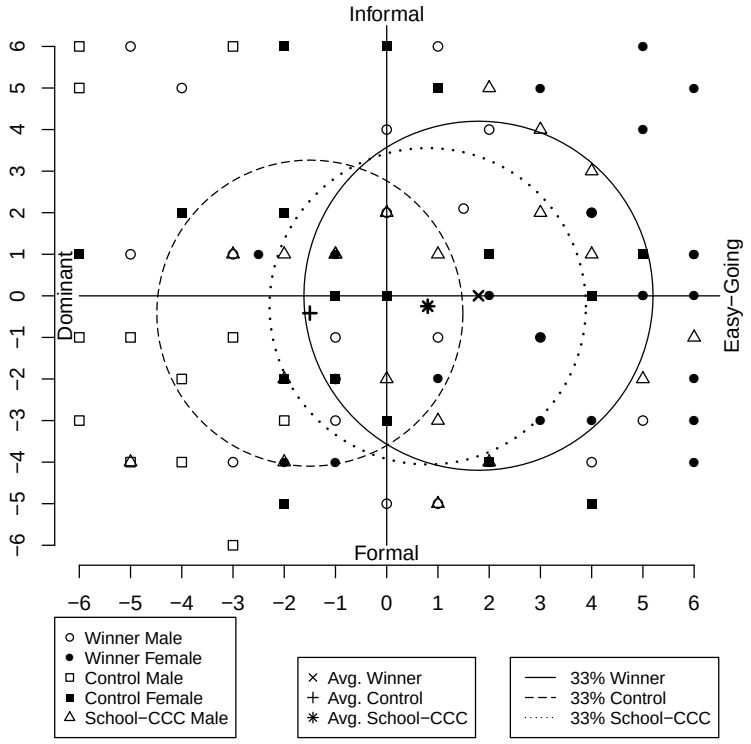

Fig. 1. Distribution of the students of the different groups in the plane of the two personality dimensions Dominant / Easy-Going and Formal / Informal.

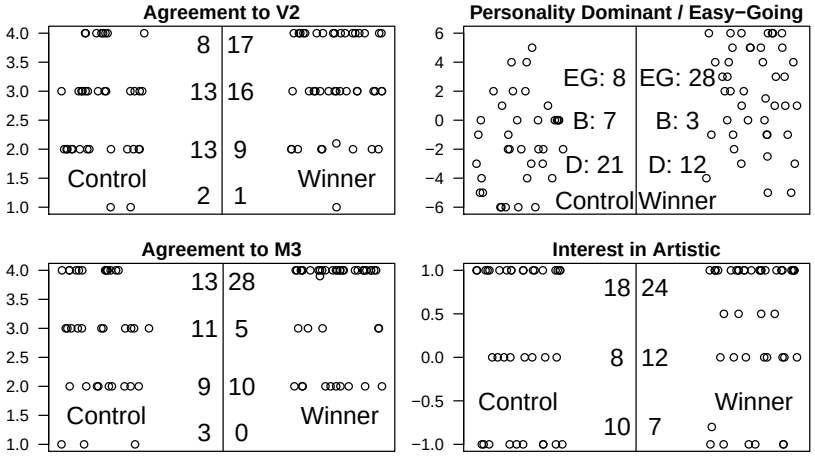

Fig. 2. Scatter plots for four of the significant factors of Table 2 against the binary variable *winner*. The x-axes contain jitter for the *winner* variable to avoid point overlap, the y-axes plot the respective factor.

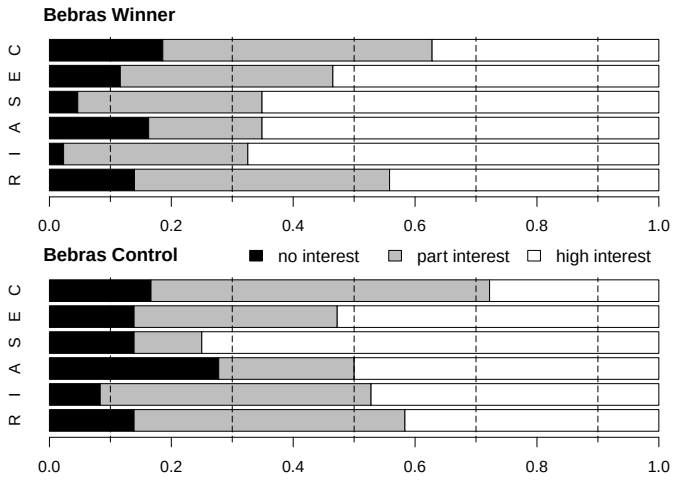

Fig. 3. Areas of interests of the Bebras participants.

support them in some sense. On the other hand, School-CCC participants might already have developed their own set of interests and have less interest in some dimensions: they are older with a mean age of 17.80 compared to the mean ages of 11.57 (winner) and 12.08 (control).

Concerning **personality**, there is a big (statistically significant) difference between the winner and the control group. Winners (and to some extent also the coding contest group) are more easy-going, neither formal nor informal, and not really dominant. Figure 1 shows this difference with mean values and quantile areas. Additionally, there is an observable difference between Bebras Winner and School-CCC participants. The latter are less easy-going than Bebras winners.

In some sense, this observation contradicts the myth that for being good in computational thinking one needs to be quite formal. Formality might be useful in some contexts, but not in the case of the Bebras contest.

Concerning **self-concept**, there are again observable differences. Bebras winner have better grades in German (so, in their mother tongue) and in Mathematics, and they also have a higher self-concept in both of the fields compared to the control group. The differences between winner and control groups are significant, and it indicates that Bebras winners do have a higher verbal and mathematical self-concept. To some sense this is not so surprising as mathematical thinking, reading and text comprehension are helpful in understanding and solving Bebras tasks. Lastly, School-CCC participants are comparable to Bebras winner, with lower verbal self-concept and grades, but still higher than the control group. To conclude, we can answer Hypotheses H1 and H2 in the following way.

(H1) Bebras winners significantly differ from the control group in respect to personality and verbal/mathematical self-concept. They are a bit more easy-going, have better grades and a stronger self-concept. They also show some differences in respect to the interests dimension.

(H2) Bebras winners significantly differ from the School-CCC group in respect to interests. They are more interested in the artistic and social domain. They also show some differences in personality (they are more easy-going and a bit more informal). Also, their verbal and mathematical self-concept and the grades are slightly better.

In order to answer the remaining hypotheses, we were taking a closer look at the correlations between the different factors and compute a regression formula, eliminating all the factors that are not contributing to the result (of winning the Bebras contest). Due to reason of space, we do not provide the full correlation tables, but Table 2 presents the significant correlation and regression factors ($p < 0.05$). It turns out that, of all the factors, personality has the highest (i.e. a medium-size) influence onto winning the contest. The verbal and mathematical self concept (V_2, M_1, M_2, M_3) and the grade in German ($VGradeActual$, lower grades are better, a negative correlation raises the chance to win) also have some influence. The regression consists of five factors for predicting a winner.

$$Winning \approx -0.147 + 0.529 \cdot SexM + 0.217 \cdot Artistic$$
$$- 0.161 \cdot Social + 0.089 \cdot EasyGoing + 0.147 \cdot M_3$$

It is notable that $SexM$ (of being a man) is part of the formula. Table 1 shows that $SexM$ and being *artistic* or *easygoing* are highly correlated, so $SexM$ is somehow a corrective factor in the formula to fit both, male and female winners.

A power test was used to describe the power of the employed correlation test. For the combined Bebras participants group ($n = 79$) and a significance level of 0.05 and a test power of 0.95, a correlation score of 0.3895 has sufficient power [6]. Therefore, only the correlation to the personality factor (Easy-Going) statistically holds with the given parameters. This does not mean that the other factors do not have any influence, and so we extended our analysis by scatter plots to look for correlations. Figure 2 summarizes the plots for four of the significant factors of Table 1 against the binary variable winner. As can be seen (data points in the area), in all the 4 plots, winners have a slightly higher verbal and mathematical self-concept, and interest in the artistic field. To conclude, we now can answer Hypotheses H3 to H5 in the following way.

(H3) The factor of personality contributes to winning the Bebras contest. The more easy-going a participant is, the higher the chance to win.

(H4) The academic self-concept contributes to winning the Bebras contest in some sense. A strong verbal self-concept and mathematical skills raise the chance to win.

(H5) General interests have some influence on winning the Bebras contest. Interests in the artistic dimension seem to help in winning the contest.

3.4 Threats to Validity

As basically all Bebras winners were at the award ceremony in Klagenfurt in 2018, we had a unique chance to reach the full population. However, the results of the study have to be taken with some care. First, the size of the population is still quite small. Even though some of the findings are statistically significant,

some others are, up to now, of anecdotal evidence. Secondly, the results might not be transferable to other countries. There also is no guarantee that the findings hold for the next contests. Being aware of that, we included the coding contest group to get an even better picture, and the results seem comprehensible.

Some of the data has been collected in written form, so there might have been errors during data-transfer. However, we checked all the data several times, following a four-eye-principle. The statistical analysis has been done with the R framework, so, we assume the data and the results to be valid.

4 Recommendations

In the light of the results we now dare some prudent recommendations, with the objective to even raise the chance to win a Bebras contest in the future.

At first, it is apparent that Bebras winner are interested in a lot of different domains, they are artistic, social, and are good and feel confident in their mother tongue and in Mathematics. The winners are also a bit more of an ease-going personality and of an investigative nature. At the beginning we raised the question if the Bebras contest is attractive to everybody. In the light of the results we can give a defensive "Yes" as an answer. The differences to the control group are not that big, and it is the creativity in the Bebras tasks and the social event (often the whole class takes part) that is a strong argument for its attractiveness.

Now, in order to raise the chance of being a Bebras winner, educators should try to do the following: (a) keep pupils interested and open-minded, (b) support social activities whenever possible, (c) try to provide more incentives to also attract dominant pupils, and finally, (d) try to increase the mathematical and verbal self-concept whenever possible.

5 Summary and Outlook

In this paper we took a closer look at different types of personality, self-concept and interests of the winners of the Bebras contest in Austria and compared them with a control group and group of pupils taking part at a programming contest. It turned out that (in our setting) there is a significant difference between the Bebras winners and the control group in the personality, self-concept and interest dimensions. We also looked at factors predicting winning the contest, and it turned out that a strong verbal self-concept and mathematical skills, as well as artistic interest and an easy-going personality have a positive influence.

Due to the small group sizes there are for sure many more things to learn, and so we are currently working on making the KAUA platform more popular and continue collecting RIASEC, personality and general interest data, and we also plan to repeat the study for the next and upcoming contests.

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