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ABSTRACT

Considering the reported lack of interest in the STEM-domain and the consequential difficulties in recruiting talented and interested young academics, the development of effective enrichment measures is indispensable. This requires a precise picture of students' interests. The paper presents an approach to characterize interest profiles in explicitly science-related activities. Adapting Holland's RIASEC-model, an instrument was developed and tested which allows the description of interest in activities along Holland's dimensions (and a seventh dimension *networking*) within the confined science domain. The findings of a study with $N = 247$ students (age cohorts 12–19 years) uncovered interest differences for the environments school, enrichment, and (prospective) vocation. The mutual importance of the performed activity and the environment the activity is performed in is confirmed by a cross-classified model. Contrasting different subgroups revealed multiple results, e.g., girls showed more interest in *artistic* and *social* activities within the science domain. High achieving students showed more interest in science-related activities in all dimensions. In conclusion, using our adapted model, students' interest structure can be described in a differentiated manner. This could lay the foundation for further analyses of students' interest profiles and thereby contribute to future development of effective and congruent enrichment measures, thus enhancing interest in science.

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Interest in science; Holland's RIASEC-model; learning environments; group differences; ICoN

Science education has undergone major changes in the last decades. Science is no longer taught and learnt at school only; media such as TV-shows or magazines, science centers, science festivals, or out-of-school laboratories at universities and industries offer a broad spectrum of science-related activities in addition to regular school classes. Moreover, school science has experienced many changes, regarding both curriculum emphases (Roberts, 1982) and required activities (Sevian & Talanquer, 2014). Based on the concept of scientific literacy, different goals and areas of competence have been pointed out for science education. Next to the learning of the basic concepts, students should understand how scientific evidence is generated, how they can apply scientific knowledge

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for socio-scientific issues of relevance and how science is communicated (e.g. Bybee, 2006; Prenzel et al., 2007). Science standards in different countries, such as the new U.S. framework (Next Generation Science Standards NGSS; National Research Council, 2013), have therefore enlarged and changed their emphases, including different scientific practices (Waddington, Nentwig, & Schanze, 2007).

This broader spectrum of science-related activities correlates with the more diverse field of professions based on or related to science. It is no longer just the prototypical individual working in a lab with goggles and a lab-coat. Scientists also work in research projects developing and applying computer-based models; they work in industries with vastly different tasks such as design, quality control, enterprising, and marketing; they work in administration and public institutions; and, last but not least, as teachers or journalists.

Considering all these changes, we argue that there is a need to enlarge perspectives in science education research as well. Large-scale assessment studies such as PISA have already broadened their spectrum of test items, for example, by including items on knowledge about science referring to 'nature of science' and methods of scientific inquiry (Prenzel et al., 2007). With regard to affective variables such as interest, the broad spectrum of activities is usually not represented is such a sophisticated manner. The instruments applied do not specifically investigate interest in different contexts and activities with regard to the whole spectrum of school science, out-of-school science and science-related professions. Therefore, the goal of the project presented and discussed in this paper is to fill this gap, and to develop and test an instrument that offers specific insights into students' interest with regard to the whole field of nowadays science.

Theoretical background

Interest is commonly considered as a multidimensional motivational variable including cognitive and affective facets (Hidi & Renninger, 2006; Hidi, Renninger, & Krapp, 2004). It is a result of one's interaction with the environment, respectively, an object, and thereby is always content specific (Gardner, 1996; Krapp, 2003; Schiefele, 2009; Valsiner, 1992). Interest is mostly defined in two different aspects: situational interest (emerging from the environment as a momentary psychological state), and individual interest (as an enduring and often stable disposition). The most important aspect concerning study or vocational choices is the latter one (Ainley & Ainley, 2011; Hidi, 1990, 2006; Krapp, 2002, 2003; Renninger, 2000; Schraw & Lehman, 2001).

Regarding interest in science, a general interest in science can be distinguished from an interest in single science subjects or domains (Krapp & Prenzel, 2011). Studies for both these facets have reported inconsistent results (e.g. Vedder-Weiss & Fortus, 2011, 2012). Some studies report a rather low interest in science for students at the age of 15 (e.g. Prenzel et al., 2007). Other authors report a quite high interest of 15–17-year-old students in this domain (e.g. Holstermann & Bögeholz, 2007), especially regarding applications in daily life (for 12–16-year-old students: Häußler, Hoffmann, Langeheine, Rost, & Sievers, 1998). The ROSE survey (Relevance of Science Education) described students' interest in science along different contents and contexts (Sjoberg & Schreiner, 2010). A differentiation into certain topics, contexts, and activities has also been assumed and investigated systematically by Häußler and Hoffmann (2000, 2002) for physics and Gräber (1992) for chemistry. Recently, Swarat, Ortony, and Revelle (2012) investigated the effects of elements of the learning environment like content topic, activity, and learning goal and found students to focus mainly on the form of activity rather than content topic.

For pursuing an even further differentiation of interest in science, Holland's RIASEC-model (1997) presents a promising structure. This model is often applied in the context of vocational interests and vocational choices and was originally developed for career choice counseling. In this model, students' attitudes, abilities, values, and interests in given activities are categorized into six diverse dimensions, namely *realistic* (activities connected to practical tasks), *investigative* (activities connected to intellectual tasks), *artistic* (activities connected to intuitional/innovating tasks), *social* (activities connected to informing, help, or training tasks), *enterprising* (activities connected to leading or influencing tasks), and *conventional* (recurring activities according to the book). This categorization enables a comparison with analogously rated occupations. The hexagonal structure of vocational interests has been confirmed using a circumplex model by several authors (e.g. Nagy, Trautwein, & Lüdtke, 2010; Rounds & Tracey, 1993).

The specific interest in science, though, has been coded in this model mainly as *investigative* and *realistic* (Krapp & Prenzel, 2011). Regarding the already mentioned diversity of science-related activities and careers nowadays, this focus on solely practical and intellectual activities does not represent an accurate perspective anymore. Therefore, in a first study, the authors (Dierks, Höffler, & Parchmann, 2014) have already adapted the original RIASEC-model to characterize typical activities of students in different educational contexts. The results illustrate the model's general suitability to characterize students' interests in school activities. Furthermore, a new dimension called *networking* has been included, due to the resulting structure of an exploratory factor analysis. This dimension features a peer-to-peer knowledge exchange, which is not part of Holland's original *social* dimension. The *social* dimension focuses more on doing good deeds, either by teaching (top-down-like), or directly helping other people. In contrast, the newly included *networking*-dimension implies reasoning on a comparable knowledge level and hence accounts for a different focus than the *social* dimension. The additional dimension has also been confirmed in another study (Blankenburg, Höffler, & Parchmann, 2015).

Students' interest was further differentiated into three different learning environments: school, leisure time, and enrichment. The results revealed significant differences of students' interest in relation to different environments (Dierks et al., 2014). The analysis of interest structures in different environments seems to be of rising importance, due to the growing development of enrichment measures and contributions by the media in addition to traditional school STEM education. Studies about enrichment programs mostly focus on out-of-school laboratories and on (science-)contests as fostering measures. Out-of-school labs are regarded as learning opportunities, which enhance learners' interest as well as cognitive and practical skills (Hofstein, 2004). Furthermore, they present a high potential of fostering inquiry-based learning. Yet, this potential is often not capitalized accordingly (Hofstein & Lunetta, 2004). Moreover, laboratories can act as an authentic learning environment and thereby provoke motivational increase (Glowinski & Bayrhuber, 2011; Goldman, Mayfield-Stewart, Bateman, & Pellegrino, 1998). Glowinski and Bayrhuber (2011) described the situational interest of students along the interest in experiments, the interest in application contexts of research, and the interest in the authentic learning environment. Of these three factors, only the authenticity showed a long-term effect (Glowinski, 2007). Students participating in other enrichment activities, such as science competitions show expectedly higher interest in science. Participants are more likely to be male than female (Lengfelder & Heller, 2005) and boys mostly show consistently higher interest in the typical 'male' topics (Jones, Howe, & Rua, 2000). Besides interest, other important factors for the participation in science contests are the students' socialization, general group differences, and structural characteristics of the considered contests (Feng, Campbell, & Verna, 2005). Also, the above-average motivation to achieve success in science is an attribute of participants, who are likely going to choose science-related study courses later on (Lind & Friege, 2004).

Interest interacts with other variables (cf. Jack, Lin, & Yore, 2014). For instance, the attitudes towards a school subject as well as the subjective norm are relevant concerning future course choices (Fulmer, 2014; Hannover, 1991; Masnick, Valenti, Cox, & Osman, 2010; Singh, Granville, & Dika, 2002; Weinburgh, 1995). The social aspect of science-related work seems to be important rather for girls than for boys (Sjoberg & Imsen, 1988). Students' achievement was investigated in many studies as well showing a medium correlation of interest and achievement (for mathematics: Köller, Schnabel, & Baumert, 2000). Vock, Köller, and Nagy (2013) observed different interest profiles for highly gifted and less intelligent students as well as for high-achievers and low-achievers.

Self-concept also correlates with interest and is understood as part of the declarative memory that consists of self-referred cognitive information, for example, knowledge of strengths and weaknesses, affections and beliefs (Shavelson, Hubner, & Stanton, 1976). Different self-concepts are assumed for different domains, for example, school subjects (Köller, 2004). Various evidence of a positive correlation of self-concept and the above-mentioned academic achievement exists (cf. Helmke & van Aken, 1995; Krapp, 1997). The importance of self-concept (next to interest) for students' future course choices has also been verified (Köller et al., 2000). Many of the above-mentioned factors are consolidated in the concept of identity formation (Carlone & Johnson, 2007; physics: Hazari, Sonnert, Sadler, & Shanahan, 2010).

In summary it can be stated that a good number of studies on students' interest exist. However, the results are diverse and not always explicit about specific facets of interest in science, and one reason for this might be the lack of a differentiated model measuring the variety of interest facets in relation to the authentic science activities in different environments offered to students nowadays. To be able to develop and evaluate suitable measures in the future, better knowledge on interest facets in different environments would be highly valuable.

Aims and setting of the study

The study presented in this paper is embedded in a larger project called *ICoN—Individual Concept about Natural Sciences*. The objective of this project is the consolidation of different constructs in order to accurately characterize students' interest as well as their beliefs on the nature of science and scientists (cf. Wentorf, Höffler, & Parchmann, 2015), their self-concept and their achievements in science.

This paper focuses on interest as one of the main constructs of ICoN. In a first step, the original RIASEC-model has already been adapted to characterize typical activities of students in three different learning environments (school, out-of-school, enrichment) to test whether the model was suitable as a potent framework to assess these kinds of activities of students and participants of a science contest (Dierks et al., 2014). The second step, discussed in this paper, aims at adapting the RIASEC + N-model to specific science-related activities in the environments school, enrichment, and (prospective) vocation.

The following research questions have been investigated and will be discussed in this paper:

(1) To what extent does the RIASEC + N-model provide a suitable foundation for a valid and reliable analysis of students' interest structures in science? Does the structure found in previous studies hold true?
(2) To what extend does this adapted RIASEC + N structure provide different interest profiles when the area of content (here: science) is fixed?
(3) Which insights does the adapted instrument provide concerning differences between interest structures in different environments (school, enrichment, vocation)?
(4) Which differences can be found between different groups of students?

Design and methods

To answer the research questions stated above, a questionnaire was developed which focused on science-related activities based on Holland's original dimensional structure. For validation purposes, a group of more than 200 students was analyzed with regard to their interest profiles and differences between several subgroups.

Instruments

As explained above, in the original RIASEC-model all science-related activities are allocated in the *investigative* and the *realistic* dimensions. The adaption illustrated in this paper concludes the adaption of a previous study (Dierks et al., 2014). For the adaption, the attributes of the original model were connected to matching activities for science-related vocations and activities. For example, in the original RIASEC-model, the *realistic* dimension describes mostly manual and technical activities. In a science-related occupation, this could be the performance of practical lab work. Analogous to these items, science-related school activities and science-related enrichment activities were chosen. In school, for instance, lab work is performed, but mainly with a focus on experiments following given instructions. Lab work in enrichment activities can also implicate more complex and open experiments. The differences in the three environments therefore consist of different actual tasks to ensure a valid adaption of the test items.

We are well aware of the fact that this adaption will reduce the contrast between the different RIASEC-dimensions and also slightly change the focus of some attributes. With regard to authentic science practices, this seems to be necessary to ensure validity, however, and leads to the research question whether the structure will still provide different interest profiles when the area of content is fixed.

Table 1 gives an overview of the attributes and dimensions of the original RIASEC-model and its adaption to science-related activities in the environments vocation, school, and enrichment in the RAISEC + N model.

A questionnaire with a total of 270 items measuring, among others, the interest in school activities, science-related school activities, science-related enrichment activities, and science-related vocational activities was developed. Furthermore, school grades, self-concept (scale with three items, $\alpha = .81$) and the general interest in science subjects and mathematics were included. For comparing the structures with the original model, the German version of the original RIASEC-questionnaire AIST was tested in the same questionnaire as well. The reliabilities were comparable to the ones reported for the standardized instrument, which ranged from .82 to .87 (Bergmann & Eder, 1992). The questionnaire was designed in such a way that the same items had to be answered consecutively for all three investigated environments.

Table 2 shows the reliabilities of the adapted RIASEC + N scales (the dimensional structure is based on the results of the prior study) in sum for students' interests in science-related school, enrichment, and vocational activities. In order to enhance the reliability of the *social* scale, one corresponding item had to be deleted from all three environments, resulting in only 9 instead of 12 items for this scale. Furthermore, the table shows the reliabilities for the same items if (a) bundled into the three environments school, enrichment, and vocational activities and (b) splitted into RIASEC + N dimensions *and* environments.

Apart from very few cases, all scales' reliabilities are satisfying to excellent, confirming the assumed structure.

Participants

A total number of $N = 247$ students of grades 8–12 (age cohorts 12–19 years, $M = 15.07$, SD = 1.214, 59% female, 41% male) participated in the study from May to July 2012. More than 80% of them were between 14 and 16 years old. All students came from three different regular secondary schools with mostly urban catchment in northern Germany. The schools were selected out of a database of research-assisting schools in the state of Schleswig-Holstein. Within these schools, various classes of different grades were selected for participation. Students' parents consented to their children's participation in the study. The students were handed the questionnaire by trained personnel and filled it in a quiet environment. The whole procedure took about 60 minutes.

Data analysis

The analysis of the data was conducted using Mplus 5.2 and SPSS. Mplus was used to calculate the CFA and the reliabilities of the scales. All correlations and t-tests were calculated with SPSS. The structural equation models were calculated with Mplus as well.

Results

In order to test whether the adapted RIASEC + N model still provides a differentiating structure when all items are set in the domain of science, the correlation coefficients r between the dimensions of the original RIASEC-model and the adapted dimensions (RIASEC + N) in the three environments were calculated (Table 3).

The r values for the corresponding scales between the original RIASEC-model and the adapted model in the environments—bold in Table 3—are generally in a medium range between .3 and .7. The correlations are larger between corresponding scales (e.g.

Table 1. Attributes and activities of the original and the adapted RIASEC + N model.

Dimensions	Realistic	Investigative	Artistic	Social	Enterprising	Conventional	Networking
Attributes	Technically adept	Analytic, task-oriented	Creative	Sociable, caring	Leadership	Conforming, precise	–
Holland's occupations	Carpenter, mechanic	Scientist, Researcher	Musician, Actor	Nurse, Teacher	Manager, Politician	Secretary, Clerk	–
Science-related vocational activities	Performing lab experiments	Developing new theories	Emphasizing linguistical and visual aspects	Teaching science	Managing science projects	Administrating a science project	Exchanging knowledge with colleagues
Science-related school activities	Performing given lab experiments	Solving theoretical problems	Emphasizing linguistical and visual aspects	Explaining sth. to classmates	Managing group works in class	Organizing the chemicals storage	Debating with classmates
Science-related enrichment activities	Performing open lab experiments	Solving challenging theoretical problems	Emphasizing linguistical and visual aspects	Explaining sth. as an expert to novices	Managing out-of-school projects	Administrating out-of-school projects	Discussing with like-minded adolescents

Table 2. Reliabilities for overall RIASEC + N (9/12 items) scales, overall environmental scales (27 items), and combined scales (each with four items (social: three items)) regarding interest in science-related activities (on a five-point-Likert scale).

Dimension	Exemplary item	Environment	α	$\alpha_{overall}$
Realistic (12 items)	'I'm interested in conducting experiments according to given instructions'	School	.65	.87
		Vocation	.79	
		Enrichment	.77	
Investigative (12 items)	'I'm interested in investigating the cause of phenomena'	School	.71	.90
		Vocation	.82	
		Enrichment	.81	
Artistic (12 items)	'I'm interested in designing science topics by means of aesthetic criteria'	School	.68	.89
		Vocation	.75	
		Enrichment	.78	
Social (9 items)	'I'm interested in explaining science topics to others'	School	.75	.90
		Vocation	.81	
		Enrichment	.81	
Enterprising (12 items)	'I'm interested in supervising others in conducting experiments'	School	.71	.90
		Vocation	.75	
		Enrichment	.79	
Conventional (12 items)	'I'm interested in sorting and administrating the chemicals storage'	School	.65	.87
		Vocation	.62	
		Enrichment	.73	
Networking (12 items)	'I'm interested in comparing thoughts with others about science topics'	School	.79	.93
		Vocation	.88	
		Enrichment	.87	
		School (27 items)		.92
		Vocation (27 items)		.95
		Enrichment (27 Items)		.96

investigative and investigative) than between different scales (e.g. investigative and artistic). It should be noted, however, that our *realistic*-items have larger correlations with the original *investigative*-items than with the *realistic*-items of the RIASEC instrument.

In order to analyze the interest structures within one setting, the intra-correlation coefficients r were calculated for the original RIASEC instrument (cf. Table 4), and, respectively, for the adapted versions for each environment (cf. Tables 5–7).

While the correlations for the original RIASEC instrument indicate rather large differences between the dimensions, the correlations are much higher for the adapted instruments where all activities are set in the science domain. The influence of the domain is thereby obvious. Still, the correlations between the traditional science dimensions *realistic* and *investigative* are also higher than all other correlations in the adapted versions.

The third research question focused on interest differences between the different settings or environments of scientific activities (school, enrichment, vocation). A cross-classified model (cf. Brunner, Nagy, & Wilhelm, 2012; Eid & Diener, 2006) was calculated to consider the hierarchical structure of the data (Figure 1). On the left side, the already established seven dimensions of the adapted RIASEC + N model are depicted, on the right side the three environments (school, enrichment, vocation) are shown. The middle column shows the questionnaire's scales (e.g. *R Sch* stands for *realistic* tasks

Table 3. Correlation coefficients *r* for the dimensions of the original RIASEC-model and the adapted instruments for interest in science-related school activities (upper line), enrichment activities (middle line), and vocational activities (lower line).

		Original RIASEC-model					
		R	I	A	S	E	C
Adapted RIASEC + N model	R	**.322***	.444***	.295***	.261***	.131*	.271***
		.358*	.488***	.297***	.245***	.120	.297***
		.472*	.674***	.191**	.111	.014	.287***
	I	.282***	**.524***	.297***	.221***	.218**	.246***
		.359***	**.569***	.285***	.204**	.191**	.315***
		.431***	**.688***	.225***	.132*	.161*	.334***
	A	.189**	.356***	**.544***	.298***	.190**	.241***
		.227***	.386***	**.426***	.273***	.156*	.333***
		.271***	.467***	**.411***	.232***	.137*	.318***
	S	.173**	.433***	.297***	**.446***	.347***	.259***
		.265***	.506***	.219**	**.337***	.293***	.299***
		.283***	.570***	.195**	**.292***	.244***	.290***
	E	.243***	.416***	.184**	.323***	**.502***	.372***
		.268***	.464***	.171**	.294***	**.410***	.394***
		.320***	.572***	.117	.208**	**.353***	.377***
	C	.208**	.287***	.228***	.235***	.163*	**.397***
		.261***	.369***	.244***	.216**	.140*	**.415***
		.325***	.504***	.168**	.119	.087	**.450***
	N	.211**	.488***	.214**	.225***	.293***	.334***
		.278***	.539***	.208**	.190**	.198**	.361***
		.326***	.621***	.143*	.125	.174**	.359***

*$p < .05$.
**$p < .01$.
***$p < .001$.

within *school*). The numbers above the arrows indicate correlations between factors or factor loadings between factors and scales, respectively. On the right side, the remaining error variances are depicted. MPlus was used to calculate correlations and goodness-of-fit statistics, which include RMSEA (root-mean-square error of approximation), SRMR (standardized root-mean-square residual), CFI (comparative fit index), TLI (Tucker–Lewis index), the value of chi-square, and the number of degrees of freedom.

The overall fit of the cross-classified model was good considering that the CFI and the TLI reached values above .95. RMSEA and SRMR values under .08 indicate an acceptable fit (Marsh et al., 2010).

Alternative models were considered but did not prove to fit the data: Neither did the RIASEC + N model on its own nor did the environment model alone fit the structure adequately. Moreover, a RIASEC-model without the additional *networking* dimension as well as another cross-classified model with RIASEC instead of RIASEC + N proved to fit superiorly (Table 8).

Table 4. Correlation coefficients *r* for the dimensions of the original RIASEC-model.

	R	I	A	S	E	C
R	1					
I	.655***	1				
A	−.054	.055	1			
S	−.085	.004	.534***	1		
E	.043	.070	.288***	.560***	1	
C	.295***	.323***	.171**	.374***	.551***	1

**$p < .01$.
***$p < .001$.

Table 5. Correlation coefficients *r* for the dimensions of the interest in science-related school activities.

	R	I	A	S	E	C	N
R	1						
I	.717***	1					
A	.631***	.637***	1				
S	.597***	.665***	.548***	1			
E	.541***	.571***	.459***	.733***	1		
C	.625***	.445***	.416***	.465***	.486***	1	
N	.600***	.677***	.607***	.684***	.655***	.456***	1

***$p < .001$.

Table 6. Correlation coefficients *r* for the dimensions of the interest in science-related enrichment activities.

	R	I	A	S	E	C	N
R	1						
I	.825***	1					
A	.765***	.768***	1				
S	.718***	.789***	.680***	1			
E	.612***	.712***	.602***	.833***	1		
C	.754***	.653***	.618***	.612***	.606***	1	
N	.735***	.789***	.782***	.776***	.730***	.598***	1

***$p < .001$.

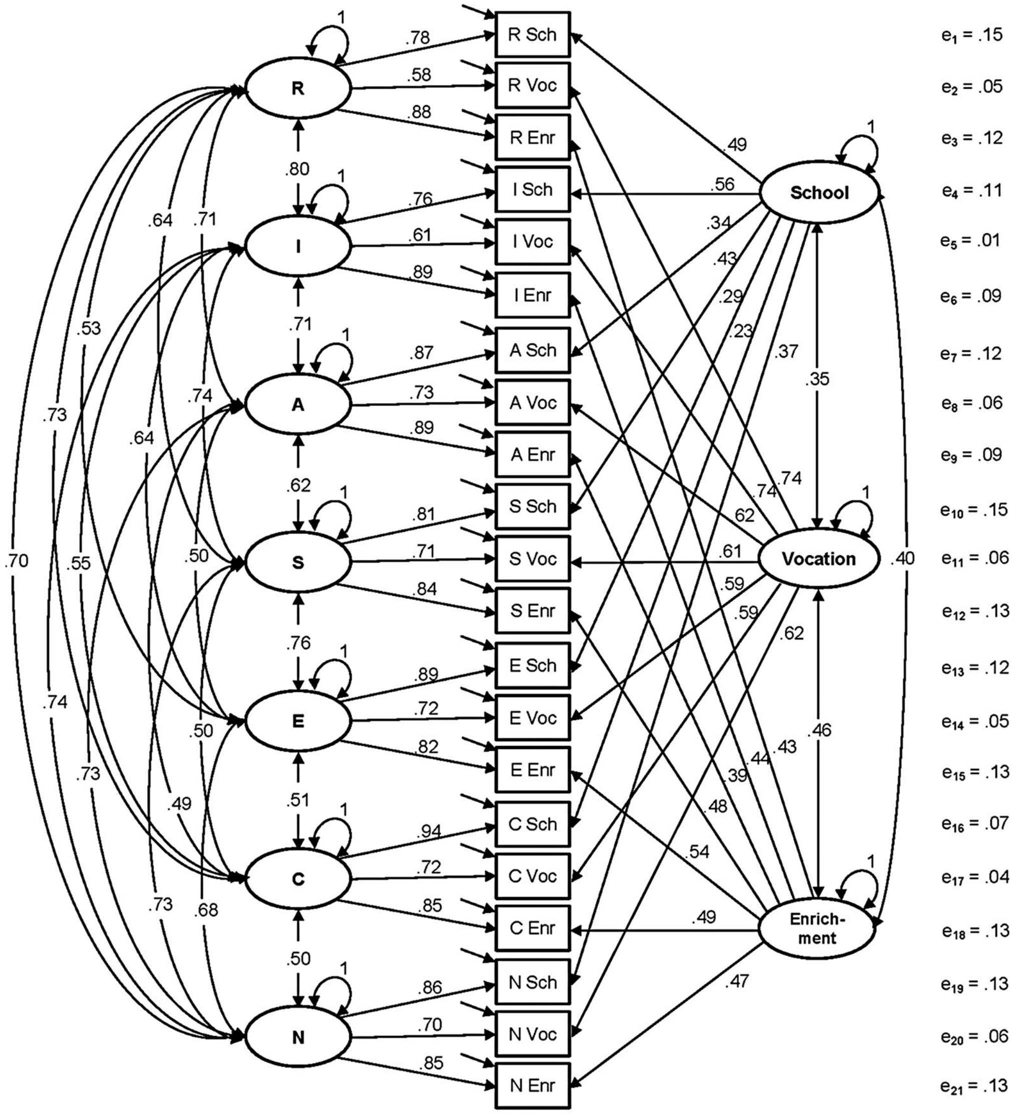
Table 7. Correlation coefficients *r* for the dimensions of the interest in science-related vocational activities.

	R	I	A	S	E	C	N
R	1						
I	.802***	1					
A	.713***	.749***	1				
S	.708***	.773***	.663***	1			
E	.633***	.724***	.608***	.787***	1		
C	.709***	.596***	.533***	.548***	.576***	1	
N	.729***	.789***	.729***	.754***	.723***	.581***	1

***$p < .001$.

The different scales (depicted in the middle of Figure 1) load generally high on the respective RIASEC + N dimensions (with one exception on the R-dimension) and less so (in the medium range) on the respective environments. The correlations between the RIASEC + N dimensions are medium to large, the correlations between the three environments small to medium, which justifies the consideration of different environments even further.

To answer the last research question about differences between groups of students, for example, gender, achievement (school grades), or science-related self-concept, independent two-sample *t*-tests were conducted. Differences regarding gender (male ($n = 102$) vs. female ($n = 145$)), achievement (students with a good or very good mean grade in science subjects and mathematics <2.45 ($n = 126$) vs. students with a mean grade in science subjects and mathematics ≥2.45[1] ($n = 115$)), science-related self-concept (students with high self-concept ($n = 152$) vs. students with low self-concept[2] ($n = 69$)), and general interest in science subjects and mathematics (students with high interest ($n = 140$) vs. students with low interest ($n = 71$)[3]) were investigated.



Goodness-of-fit indices:

$\chi^2 = 291.615$, $p < .001$, $df = 144$, $\chi^2/df = 2.025$

CFI = .977, TLI = .967, RMSEA = .065, SRMR = .051

Figure 1. Standard estimations for the cross-classified model describing the structure of interest in science activities and GOF indices.

Girls' interest in the *artistic* dimension was higher than the boys' interest in school as well as enrichment activities (Figure 2). Likewise, girls' interest in *social* school activities was higher than boys', whereas no significant differences could be observed in the *investigative*, *enterprising*, *conventional*, and *networking* dimensions (Figure 2). In the *realistic* dimension, boys showed a significantly higher score in the science-related vocational

Table 8. GOF indices for the cross-classified model, the RIASEC + N model and the environment model to describe the structure of interest in science activities.

Model	χ^2	*df*	CFI	TLI	RMSEA	SRMR
Cross-classified model (7 + 3 factors)	291.615	144	.977	.967	.065	.051
Cross-classified model (6 + 3 factors)	798.282	153	.900	.863	.131	.107
RIASEC + N model (7 factors)	2325.468	168	.672	.590	.228	.100
RIASEC-model (6 factors)	2440.839	174	.650	.577	.230	.096
Environment model (3 factors)	2628.435	186	.629	.581	.231	.083

Note: All χ^2 GOF tests were statistically significant at $p < .001$; CFI = comparative fit index; TLI = Tucker–Lewis index; RMSEA = root-mean-square error of approximation; SRMR = standardized root-mean-square residual.

interest, while girls seem more interested in realistic science-related school activities and enrichment activities.

Figure 3 displays the results for interest differences according to achievement groups. Here, high-achieving students showed higher interest in all dimensions and all environments. The largest significant effects could be found in the *investigative*, *artistic*, *social*, and *networking* dimensions, but no significant differences could be observed in the *conventional* dimension.

Disparities in students' science-related self-concept also correlated with different interest characteristics (Figure 4). In the three adapted environments, students with higher self-concepts showed (mostly significantly) higher interest in all dimensions. Overall, the largest differences have been found in the *realistic*, *investigative, social*, and *networking* dimensions, whereas again in the *conventional* dimension nearly no significant differences could be seen, with an exception of the interest in science-related vocational activities.

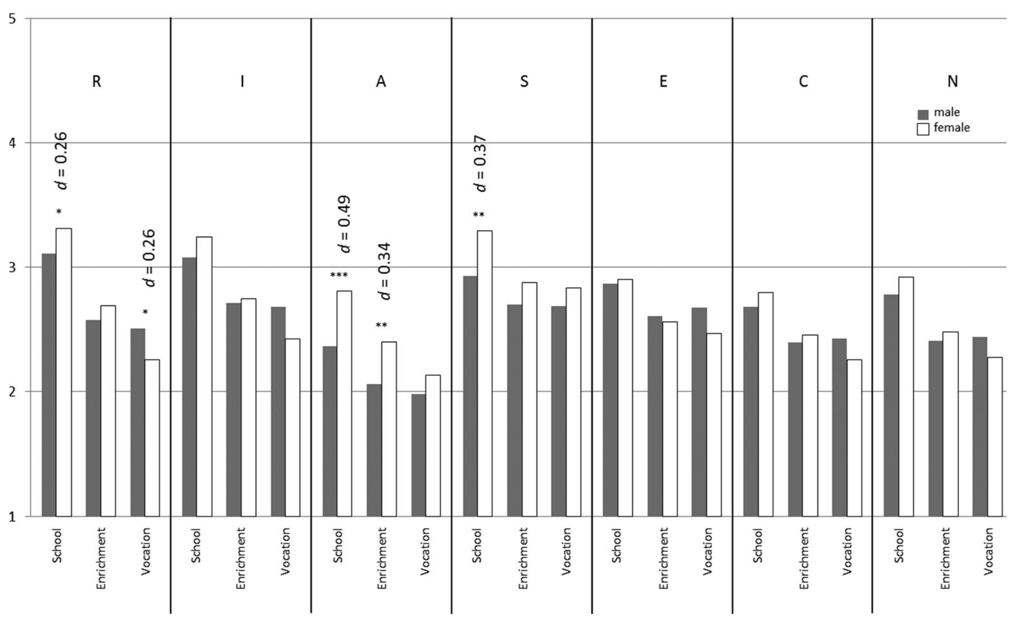


Figure 2. Results of the *t*-test on gender effects: interest in science-related school, enrichment and vocational activities.

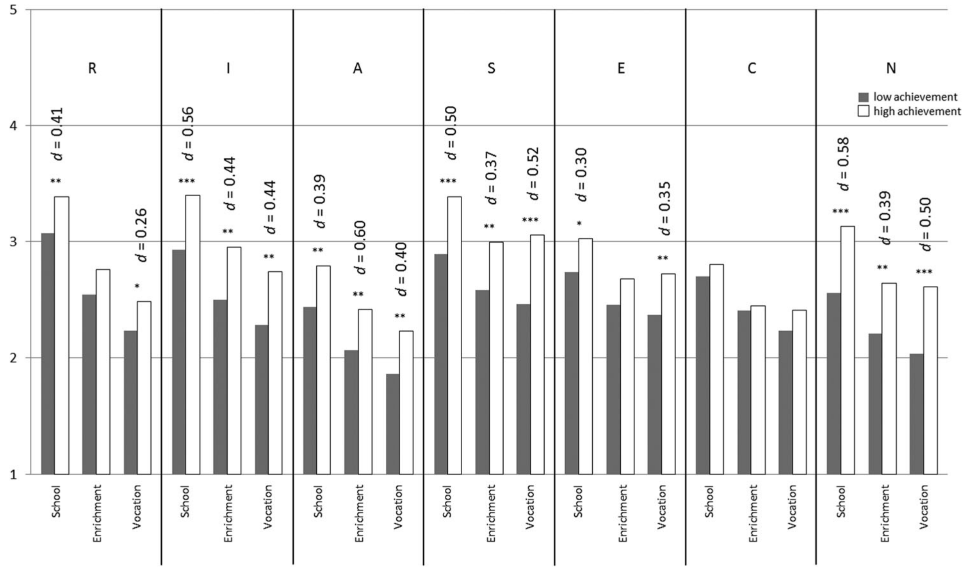


Figure 3. Results of the *t*-test on achievement: interest in science-related school, enrichment and vocational activities.

Figure 5 depicts the results of the *t*-tests on students' general interest in science subjects and mathematics. Generally higher interested students showed a higher interest in science-related activities in all dimensions and all environments, which supports the validity assumption of the chosen activities for the adapted RIASEC items. Again, some of the largest differences could be observed in the *realistic*, *investigative*, *social*, and *networking* dimensions along all environments (with large effect sizes up to $d = 1.12$), while the differences in the *artistic and conventional* dimensions are lower. Differences in the interest in

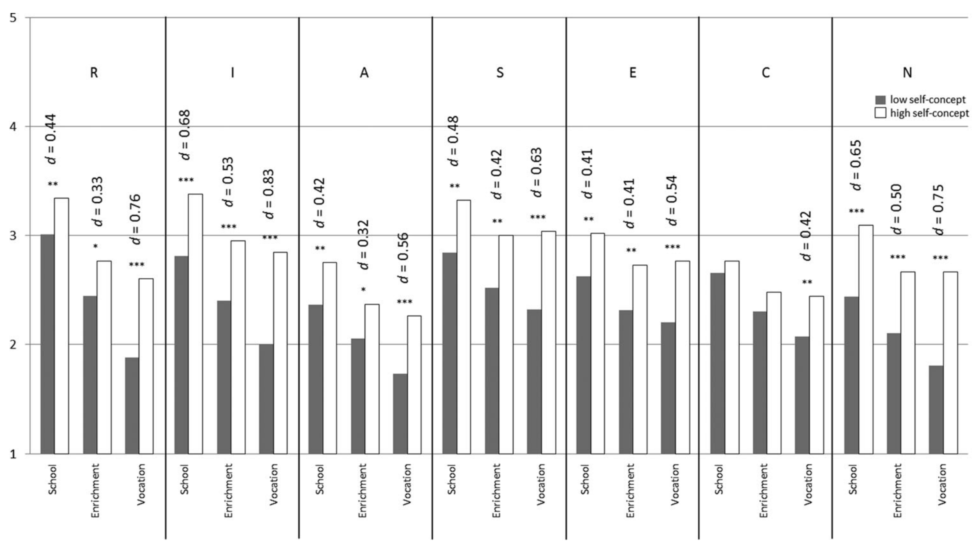


Figure 4. Results of the *t*-test on self-concept: interest in science-related school, enrichment and vocational activities.

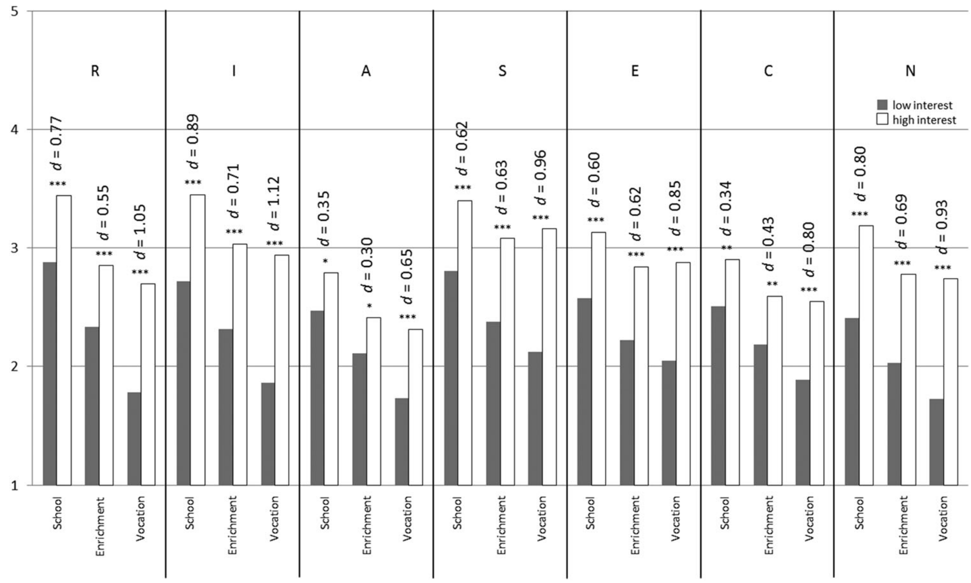


Figure 5. Results of the *t*-test on interest in science subjects and mathematics: interest in science-related school, enrichment and vocational activities.

science-related vocational activities in all dimensions are highly significant with $p < .001$ and effect sizes ≥ 0.53.

Discussion

This study intended to develop and test an adapted RIASEC-model able to characterize students' interest in science-related school, enrichment, and vocational activities. The aim was to confirm the eligibility of the newly developed instruments and to analyze whether the dimensional structure of interest in activities can still be observed within the science domain. Differences between different environments and different groups were analyzed subsequently to test for the suitability of the new instruments. So far, the results give good reason to assume a successful adaption of the instrument to the science domain.

Regarding the overall structure of the model, the environments are clearly to be understood as an additional impacting variable regarding students' interest. This is confirmed by the GOF criteria of the alternative models presented (solely RIASEC + N vs. solely environments). The same consideration applies to the activities actually performed by the learners, respectively, their corresponding RIASEC + N dimensions. According to the cross-classified model, the activities are also not sufficient to be solely taken as the variable predicting students' interest. The results reveal the syndetic, mutual significance of both, activity and environment, for the precise characterization of students' interest within the science domain. This is also supported by other ongoing studies in comparable contexts, which also identified a cross-classified structure (Blankenburg et al., 2015). These findings also support the validity of this instrument.

Concerning the first two research questions, whether the adapted model is adequate to profile students' interest in science-related activities along an adapted RIASEC-dimensional structure, the calculated correlations between the original model and our adaptation support the expected characterization along the adapted RIASEC + N model. The relatively large correlations between items from the corresponding dimensions of the original model and the adaptation demonstrate their overall relation. On the other hand, the fact that those correlations are nowhere near 1 suggest that our science-focused adaptation indeed measures a distinct concept and has therefore certain additional value.

In order to assess the domain's influence (here: science), the correlations within the dimensions of the original and adapted models were calculated. The correlations within the original model are diverse (ranging from −.085 to .655***) while the correlations within the adapted model are generally medium to large (ranging from .416*** to .833***). This can be considered as an indication for the consistent influence of the science domain on the interest of students. It can be stated that the science domain as well as the actually performed activities both impact students' interests in science-related activities. While the original AIST instrument measures a combined effect of an activity in a typical, stereotype domain, our adapted instruments allow to measure interest profiles for activities within the science domain. The correlations for the typical science-related activities named *realistic* and *investigative* are higher than those to all other dimensions. The inter-correlations of the corresponding dimensions between the different instruments (e.g. between all R-dimensions) confirm the validity of the structure meanwhile. The value of the additional *networking* dimension, which was found for the first time in a previous study, could be further supported, as the tested '+N'-models proved to be superior regarding goodness-of-fit criteria to RIASEC-models.

In summary, the adapted RIASEC + N model presents a supplement to a more profound characterization of students' interests within the science domain by permitting a categorization of students' interests in specifically science-related activities along the seven dimensions of the adapted model. The positive results of the CFA, especially the good reliabilities, provide the eligibility for representing the expected structure of students' interests.

Regarding the third research question whether differences in students' interests could be observed according to the three environments school, enrichment, and prospective vocation, comparatively large and significant factor loadings within each of the three environments were found. Those might indicate that respective activities are perceived quite conjoined for the environments within the science domain. Moreover, in some cases, items had quite small loadings on the latent factors regarding the three environments, which indicates the larger importance of the RIASEC + N dimensions in those cases. In other cases, the opposite was true (especially regarding vocational activities). Nevertheless, the introduced cross-classified model confirms the additional importance of the different environments regarding students' interests. This finding is in line with the theoretic considerations we made before developing the items: Different environments reflect different aspects of students' experiences. For example, investigative activities in school often consist in solving given theoretical science-related problems, mostly in a rather predetermined manner. In well-equipped enrichments programs, however, participants might get the opportunity to spend much more time on searching for the right way to solve science-related problems, closely related to the *investigate* dimension of the model. Therefore, each environment still plays a distinct role in explaining students' interest in science activities—also indicated by only small to medium correlations between all environments. Interest in vocational activities, for example, seems to be often different to interest in the same activities in school or in an enrichment measure.

Research question four aimed to test whether the instruments are suitable to characterize interest differences for different groups of students. With regard to gender differences, girls showed the anticipated higher interest in activities of the *social* and *artistic* dimension in some but not all environments (cf. Sjoberg & Imsen, 1988). Thus, these activities still seem to be subject to existing gender stereotypes. The interest in activities of the *social* dimension have high values overall for both boys and girls, showing a quite comprehensive interest across the environments. In contrast, the interest in activities of the *artistic* dimension is very low, especially for boys, again alluding towards stereotype notions.

The result that the boys' interest in the *realistic* dimension is higher only in science-related vocational activities but *not* in the school and enrichment environments indicate the influence of the environment again. *Realistic* activities such as mechanical craftwork are typically perceived as male professions (cf. Kessels, Rau, & Hannover, 2006). In school, on the other hand, it may be that girls often carry out supporting activities in experimental settings, without taking the leadership. This habit might then explain the different results for this dimension, especially in the settings school vs. vocational activities, but this explanation is mainly speculative at this point.

For the group of high-achievers in science subjects and mathematics higher interest was identified for all dimensions. Especially in the *artistic*, *investigative*, and *networking* dimensions the differences are relatively large. This might be explained for the two latter ones by the high degree of specific subject-related knowledge required for corresponding activities. The results of other studies (Vock et al., 2013) that lower achieving students show higher interest in *realistic* (and *conventional*) dimensions could not be reproduced in this study. The results of the original RIASEC-questionnaire, though, showed comparable results; not shown in the results due to the paper's focus). Hence, this outcome probably originates in the science-related domain, integrating experimental activities in some dimensions. Especially these lab work-related activities are often reported to cause high interest in learners on the context at hand (Hofstein & Lunetta, 1982). Setting up realistic activities in classrooms might not capture the *realistic* dimension very well. This finding once more emphasizes the importance of precise analyses of domain-related interest profiles rather than general interest in single subjects.

Differences regarding students' self-concept show a similar picture: Students with high self-concept consistently displayed higher interest in all environments and in all dimensions. Again, the differences in the investigative and networking dimensions were notably large, which could be explained analogously to the findings for interest differences depending on students' achievement.

As to students' general interest in science subjects and mathematics, the results follow the same scheme: Highly interested students showed higher interest in all dimensions and all environments with quite large value distinctions. This might be explained by the independent variable *general interest in science*, which measures the same overall construct as the dependent variable *dimensional structured interest in science-related activities*, only on a more general level. These results might reflect the relation between the individual interest and situational interest in this educational and vocational science context (cf. Hidi & Renninger, 2006; Krapp, Hidi, & Renninger, 1992).

Of course, there are certain limitations of the study. Further studies increasing the sample size and expanding the grade band/age level and the area of survey might be in order. The actual sample size is rather small but for the purpose of this study sufficient. The aim was to test for validity, reliability, and suitability of the adapted instruments only as a foundation for future comprehensive studies. In addition, the high correlations between the adapted *realistic* dimension and the original *investigative* dimension (even higher than between the two *realistic* dimensions) raise questions. So far, this can only be explained by the proximity of the dimensions for the science domain in the original model and thereby a possible impact on activities within precisely this domain. The comparatively large correlations of all other adapted dimensions with the original *investigative* dimension support this hypothesis. However, in order to clarify these findings, they should be object to further research, preferably in a pre-post-setting.

Conclusions and outlook

In summary, the adapted RIASEC + N model proved to be eligible to describe students' interests in science-related activities in a differentiated way, which much better mirrors the broader spectrum of science-related activities nowadays. The assumed dimensional structure of interest (including the *networking* dimension) could be reproduced for activities within the science domain. Furthermore, the application of the instrument uncovered group differences regarding gender, self-concept, achievement, and general interest in science subjects. Thereby, often-reported differences were confirmed (e.g. girls showing higher interest in *social* and *artistic* activities), while other relevant distinctions could be observed (e.g. higher achieving students and students with higher self-concept showed higher interest in *investigative* and *networking* dimensions, presumably due to the substantial subject-related knowledge).

Concerning the future development of enrichment measures, first implications can be stated: Aiming at the most precise support of students by providing enrichment measures and fostering programs with the highest possible congruency to actual interest profiles in science-related activities, the orientation and the target groups of the contests need to be characterized. Based on further analyses of interest profiles of participants of the diverse science contests, matching combinations can be identified. For those interest foci which are not represented by the orientation of any enrichment programs, new matching measures must be developed. Thereby, students can be guided to the corresponding programs more effectively, providing better fostering and enrichment measures in order to stimulate long-term interest in the science domain.

Notes

1. In the German grading system, grades range from 1 to 6 with 1 being the highest and 6 being the lowest grade. All mean grades lower than 2.45 are 'good' or 'very good', all grades higher than and including 2.45 are merely 'satisfying' (3), 'sufficient' (4), 'inadequate' (5), or 'insufficient' (6).
2. In this paper, we define high self-concept as a mean value >3 on a five-point-Likert scale (1 to 5) and a low self-concept as a mean value <3. Students who did not indicate a clear tendency (i.e. with a mean value of 3) were disregarded for this particular pair-wise comparison.

3. In this paper, we define high general interest as a mean value >3 on a five-point-Likert-scale (1 to 5) and a low general interest as a mean value <3. Students who did not indicate a clear tendency (i.e. with a mean value of 3) were disregarded for this particular pair-wise comparison.

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