Journal of Gifted Education and Creativity,
7(2), 73-82, August 2020
e-ISSN: 2149- 1410
jgedc.org

Young Wise Publishing
youngwisepub.com


***Research Article***

# Long-term effects of the enrichment program "Kolumbus-Kids" – Differences in the career paths of former participants

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**Article Info**

*Received:* 10 June 2020
*Revised:* 29 July 2020
*Accepted:* 02 August 2020
*Available online:* 15 August 2020

*Keywords:*
Biographical research
Enrichment-program
Long-term effects
Natural scientific giftedness
Quantitative study

2149-1410/ 

**Abstract**

Enrichment programs and giftedness research have an enormous potential to support knowledge and personalities of gifted individuals. Particularly in view of the prevailing shortage of skilled workers in occupations in the natural sciences, the promotion of gifted and interested students seems to be necessary in order to motivate them for a career in this sector in the long term. The following study addresses the long-term implications of "Kolumbus-Kids"—an natural scientific enrichment program designed to promote gifted elementary and middle school students—by examining the extent to which the program exhibited lasting effects on participants' scientific self-concept, natural scientific interest and career (i.e., course) choice. Former participants of the project "Kolumbus-Kids" (N = 137) took an online-survey to collect subjective estimations of several different constructs (e.g., scientific self-concept, influence on the choice of career and/or course) in a quantitative study. We did not reveal any statistically significant differences between former female and male participants in terms of self-concept (p = .357), scientific interest (p = .868) and influence on the choice of career and/or course (p = .853). Consequentially, the project "Kolumbus-Kids" appears to simultaneously promote female and male participants, without gender playing a role. Furthermore, when compared to the national German average, the study showed that the female and male participants were three times more likely to choose a career (i.e., profession) in the field of natural sciences. This aspect leads to the assumption that the project itself may act as a positive influence on the future career choices of its participants.

**To cite this article:**
Schäfers, M. & Wegner, C. (2020). Long-term effects of the enrichment program "Kolumbus-Kids" – Differences in the career paths of former participants. *Journal of Gifted Education and Creativity, 7*(2), 73-82.

## Introduction

Although science is not among the most popular subjects in older high school students, inummerable studies have shown that primary school children have an interest in learning science (Gebhard et al. 2017; Merzyn, 2008; Steffensky et al. 2016). It has been suggested that this decline in interest could result from an increase in complexity and a greater level of theory comprehension, starting in fifth or sixth grade (Merzyn, 2008; Gebhard et al. 2017). Adverse feelings directed towards the natural sciences eventually results to a substantial lack of young scientists (Wegner & Schmiedebach, 2017). In Germany, almost half a million positions in STEM (Science, Technology, Engineering and Mathematics) fields remained vacant in 2019, due to a shortage of skilled workers (Institut der deutschen Wirtschaft, 2019; see Table 1).

Particularly in the natural sciences, gender-related differences become apparent when observing subject preferences in school, as well as in academic and career paths. Although PISA studies show that female students in Germany perform better in the natural sciences than male students (OECD, 2014), it should not go unnoticed that

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only 33% of German university students in STEM-related fields are female (Lojewski, 2011). Aside from interest, enjoyment and perceived usefulness of a particular subject [...], self-perception of one's own overall performance (self-concept), as well as the ability to cope with difficult tasks (self-efficacy) play a decisive role in the utilization of one's own performance potential (Lojewski, 2011). A passion for the natural sciences does not only depend on performance and cognitive abilities, but is determined by various additional factors, such as self-perception, family support and self-confidence. It has been suggested to make STEM-related degree programs more attractive to women to counteract the "stereotypical polarization of women's and men's occupations" (Aeschlimann et al. 2015, p. 286).

To counteract the shortage of skilled workers and the gender-related differences, many attempts have investigated reasons for a loss of interest and potential solutions. Enrichment programs and giftedness research have an enormous potential to support the knowledge and personalities of gifted individuals. By acknowledging the declining interest in natural sciences (e.g., in elementary school students) in combination with the shortage of STEM-skilled workers in Germany, the importance of continuing research in this field (e.g., fostering motivation, interest, and personality development) is indisputable. However, hardly any research has been conducted on former enrichment project participants. An influential literature investigating short and long-term effects of enrichment programs for gifted children (Schäfers & Wegner, 2020) demonstrated that extracurricular programs can positively influence short- and long-term interest (Guderian, 2006; Hausamann, 2012; Dieser, 2015), increase scientific self-concept (Markowitz, 2004; Wegner, 2009; Grosch, 2011) and result in a significant, long-term increase in knowledge (Dieser, 2015). In particular, programs with hands-on activities have a positive effect on participants (Markowitz, 2004). These projects should be started early-on in school as gifted students typically exhibit increased interest before any measure is taken to support them, where they may require special attention to strengthen their interest (Arasi, 2006; Schmitz, 2006). From a social perspective, enrichment programs can have a positive influence on emotions and intrinsic motivation (Wegner, 2009; Wegner et al. 2013), and even lead to long-term effects in the form of friendships or like-minded exchanges (Grosch, 2011; Hausamann, 2012).

**Table 1.**

*Vacant Positions (macroeconomically) according to STEM-profession Aggregates and Regional Administrations of the Federal Employment Agency. Last modified: April 2019*

| Federal State(s) | STEM-Skilled Labor | STEM-Specialized Labor | STEM-Professional Labor | STEM-Total Positions |
|---|---|---|---|---|
| **Baden-Württemberg** | 36,000 | 14,000 | 26,100 | 76,100 |
| **Bavaria** | 41,000 | 16,600 | 28,100 | 85,800 |
| **Berlin/Brandenburg** | 11,700 | 3,800 | 9,600 | 25,100 |
| **Hesse** | 15,500 | 5,700 | 10,500 | 31,700 |
| **Lower Saxony/Bremen** | 27,900 | 7,800 | 14,500 | 50,200 |
| **North*** | 18,100 | 5,600 | 9,900 | 33,600 |
| **North Rhine-Westphalia** | 53,200 | 14,900 | 24,700 | 92,800 |
| **Rhineland-Palatinate/Saarland** | 15,200 | 4,100 | 7,900 | 27,200 |
| **Saxony** | 12,800 | 4,500 | 7,800 | 25,100 |
| **Saxony-Anhalt/Thuringia** | 18,100 | 4,900 | 7,700 | 30,700 |
| **Germany** | 249,500 | 82,100 | 146,800 | 478,300 |

* Hamburg/Schleswig-Holstein/Mecklenburg-Western Pomerania

Notes. Numbers exclude positions from cooperating partners of the federal employment agency. Results are rounded to the nearest hundredth, although differences are possible.

## Theoretical Background

Interest and self-concept has a large influence on the perception of enrichment programs as well as on future school and career decisions (Schäfers & Wegner 2020). For that reason, retrospective interest, scientific self-concept and the influence on the choice of career and/or course were examined in this study. The theoretical foundation of each construct is briefly described in the following subchapters. Although the motivation is not evaluated as an individual construct, it is reflected and connects all three of the aforementioned constructs.

**Retrospective Interest**

The construct *retrospective interest* is based on Krapp's person-object-theory of interest (2010), where interest denotes a preference for certain learning content (Schiefele et al. 1993) and is understood as multidimensional, for which object specificity is a particular characteristic (Krapp, 2010). It is defined as a person-object relationship "characterized by a highly subjective appreciation for the object itself, as well as an overall positive evaluation of the emotions experienced when interacting with the respective object" (Krapp et al. 2014, p. 205). Objects are not necessarily concrete and may include thematic areas of general knowledge as well as certain activities (Krapp, 2018). Even scientific phenomena, the investigation of subject-specific questions and learning the scientific method, may form the object of interest.

Situational and individual interest are strongly distinct concepts (Krapp, 1998; see Figure 1). Situational interest develops from the interaction between the person and learning situation, is a motivational state created through the stimulating preparation of learning content and only lasts temporarily (Krapp, 1998). However, it is possible that situational interest develops into a long-lasting individual interest (Schiefele, 2009, p. 197; Krapp, 1998, p. 190). This is typically a multi-stage process, initiated by a specific characteristic of a situation, task or object (Krapp, 1998). Curiosity combined with positive feelings may transform into an ongoing willingness to engage with the object of interest in a way that is effective for learning (Krapp, 1998). Individual interest can in some cases be referred to as a stable tendency, and even become a fixed personality trait (Krapp, 2002).

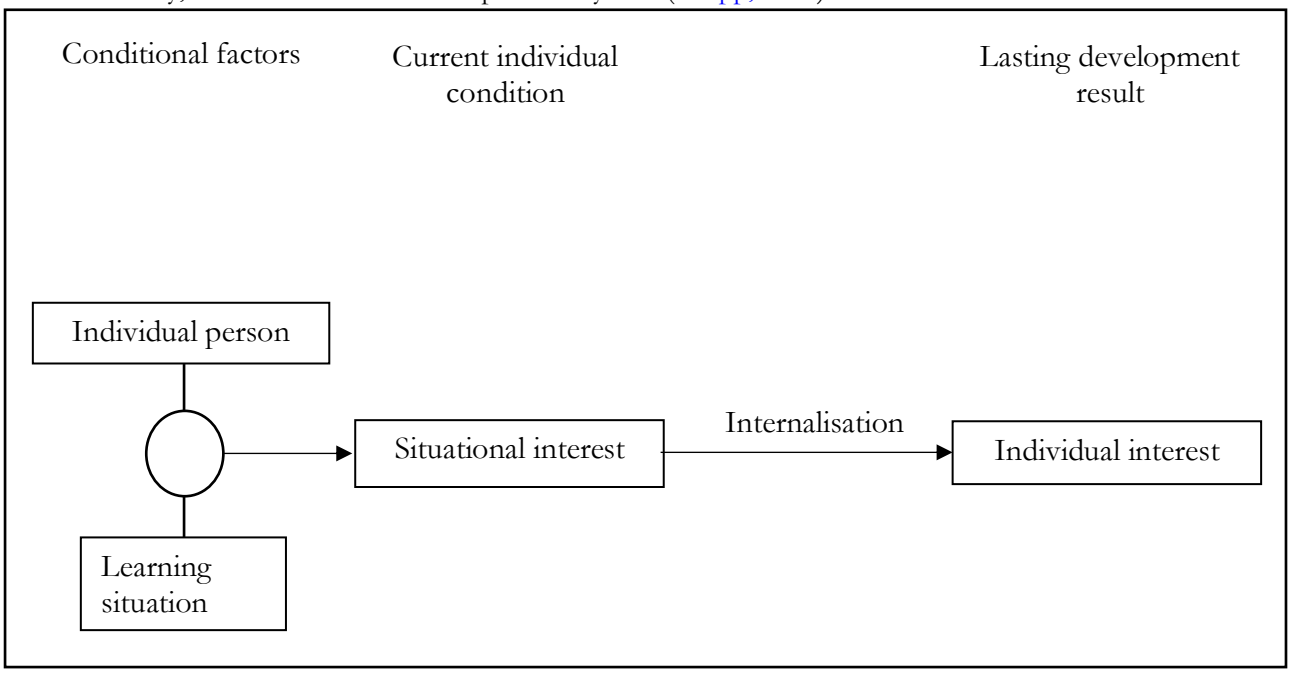


**Figure 1.**

*Framework Model for the Genesis of Interests. Source: Krapp (1998) p. 191.*

**Current, Scientific Self-concept**

Self-concept "is generally understood to be the entirety of the cognitive representations of one's own abilities" but may also be addressed as a "mental model of an individual's abilities and characteristics" (Stiensmeier-Pelster & Schöne, 2008, p. 63; Moschner & Dickhäuser, 2010, p. 760). Self-concept includes descriptions and perceptions of an individual's own abilities and weaknesses, as well as stable likes and dislikes (Krapp et al. 2014). An evaluation of these characteristics can be defined as self-esteem (Stiensmeier-Pelster & Schöne, 2008). Self-concept is a multidimensional and hierarchal structure and can be differentiated into sub-areas; the more precisely the self-concept is described, the more specific the level becomes (Moschner & Dickhäuser, 2010; Shavelson et al. 1976, see Figure 2).

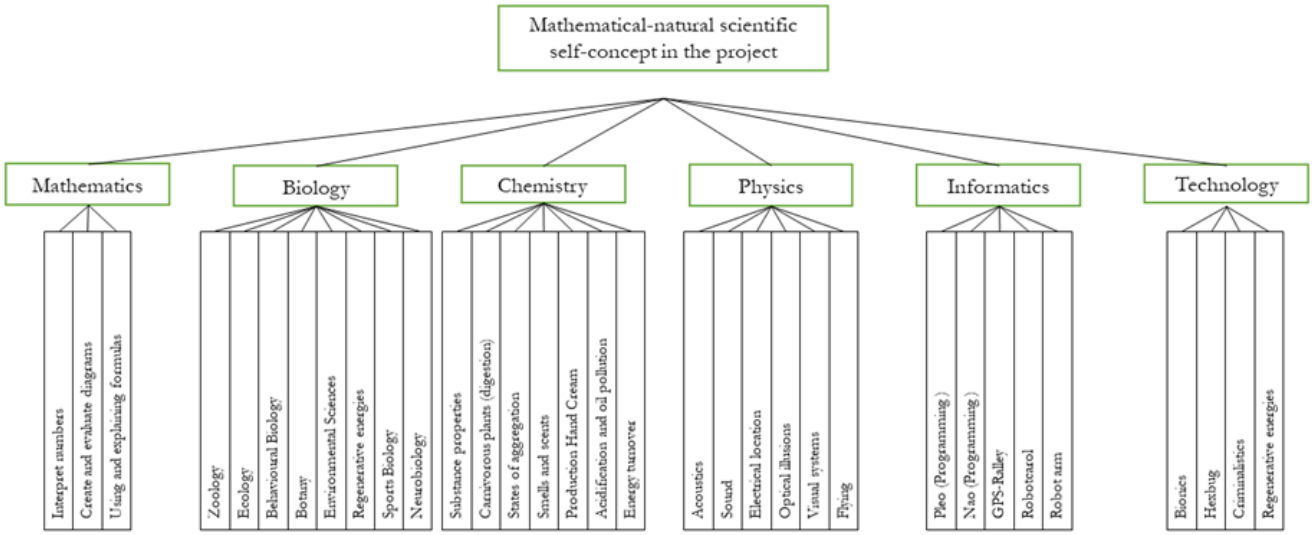


**Figure 2.**

*Mathematical-scientific Self-concept in Project "Kolumbus-Kids".*

Note. The subject-specific self-concepts are assigned to the respective project curriculum

There are noticeable gender-specific differences in scientific self-concepts. Female students rated their abilities worse than male students and are often referred to as "reserved" (Prenzel, 2007). When observing self-concept from a motivational perspective, females often show lower intrinsic and extrinsic motivation as well as joy when dealing with natural sciences (Prenzel, 2007; Schilling et al. 2006). In addition, gender differences in self-concept are even recognized in elementary school students (Dickhäuser & Stiensmeier-Pelster, 2003).

**Influence on the Choice of Course and/or Career Path**

Current university statistics show recruitment problems and high drop-out rates in university STEM majors and only 18.5% of senior students in Germany show a willingness to pursue a scientific academic major after graduating secondary school (Aeschlimann et al. 2015). While gifted students often have a wide range of talents and interests, they also have a similar and sometimes overwhelming number of possible career choices (Holling & Kanning, 1999). It is vital that these students feel as if they are choosing the right path for themselves early-on in their school career, without neglecting certain interests and abilities (Holling & Kanning, 1999).

To make matters worse, there is an unequal distribution of female and male students among different subject areas; female students are more likely to pursue disciplines such as veterinary medicine, linguistics or cultural studies, and only 31% pursue in the STEM field (Lojewski, 2011). This may be a result of particular subject requirements, as students pursuing natural science subjects find interest and talent particularly important (Lojewski, 2011). Males rate their ability to possess specialized knowledge significantly higher than females do (Buschor, Denzler & Keck, 2008) and ultimately create an illusion that they—based on their self-concept—better fulfill the requirements of the respective STEM field (Gehring et al. 2010).

**Project "Kolumbus-Kids"**

The project "Kolumbus-Kids" at Bielefeld University, Germany is an enrichment program established to promote scientifically gifted elementary and middle school students. The project takes place at Bielefeld University and is recognized as an extracurricular learning environment, where students are taught findings in psychology and neuroscience (Wegner, 2009). "Kolumbus-Kids" integrates a hands-on propaedeutic and holistic approach, combined with a strong relevance to everyday life, to foster the interests and abilities of the participants (Wegner, 2013). The primary objectives are to strengthen scientific self-concept, enable students with an environment to develop a deep interest in scientific phenomena, and obtain long-term effects pertaining to course preferences in school (e.g., biology, chemistry, physics) and career paths in science.

Lesson plans are designed uniquely for the project and are independent from the state school curriculum (Wegner, 2009). They are intented to introduce participants to scientific issues and familiarize them with subject and science-oriented approaches, as well as to apply the scientific method (Wegner & Schmiedebach, 2017). To participate, students are selected based on their logical thinking and intelligence quotient. After a six-month period of participation, students have the opportunity to re-register for the following session. This means that they may start in

fourth grade and partake in "Kolumbus-Kids" courses until the end of seventh grade. The project was founded in 2006 by Prof. Dr. Claas Wegner and has since then developed; in the last six months, approximately 150 gifted students have participated in one of ten 90-minute weekly after-school courses.

### Hypotheses

Our project "Kolumbus-Kids" goals are two-fold. First, we aim to increase and evaluate long-term effects of the project on situational scientific interests and self-concept through regular (i.e., weekly) participation and hands-on activities. By the scientific propaedeutic nature of the project, we will focus on promoting a gender-neutral academic/school-based ability self-concept (Prenzel, 2007). Futhermore, as women remain a minority in STEM-related professions, our project is designed to benefit all participants to pursue training and academic degrees in STEM-related fields (Lojewski, 2011). As a result, we hypothesize that 1) the project should similarly influence the choice of school courses and/or career path in both genders and 2) that the frequency of pursuing a career path in a STEM-related field is equally distributed in former male and female participants. Surveying scientific interest, self-concept and choice of occupation from former participants allows us to draw post-study conclusions pertaining to "Kolumbus-Kids". Second, we will optimize the test instrument (e.g., a partially self-constructed online-questionnaire) for future use in the long-term evaluation of the project "Kolumbus-Kids". We plan assess quality criteria and implement modifications which will allow us to examine different contexts, varying ages and inclination groups.

## Method

### Research Design

In August 2018, we started our research project to investigate the long-term effects of the enrichment-project "Kolumbus-Kids". In addition to researching the content of the project, the current state of research was also developed in order to be able to base the current research on similar and overlapping studies. Furthermore, a comparison of different implementation and survey methods was conducted to check the suitability for the planned project. We decided to use the online-evaluation tool of Bielefeld University, which we had to be trained in. On the basis of the technical research, the contents of the questionnaire were determined and entered into the test in the form of different constructs and items. In the following month, the survey was published and the link to the study was sent to the participants. The survey was open until November, i.e. two months, for the former participants. When the survey was closed, the processing of preparation and analysis of the data started.

### Participants

The sample consisted of gifted students who attended at least one "Kolumbus-Kids" or "Kolumbus-Youth" course between 2009 and the winter of 2015-2016. The number of participants in each course varied between five and 115 students (see Fig. 3). After excluding individuals from the study based on multiple participation or missing contact information, 556 potential participants remained. The online-questionnaire link was sent via E-mail to potential participants; E-mail addresses to which the link could not be delivered were excluded, resulting in a total of 489 former participants. A total of 137 individuals (males: n = 68, mean age = 15.93; females: n = 69, mean age = 17.07) completed the online-questionnaire (response rate of 28.4%), which is considered reasonable with respect to the amount of time that elapsed between course participation and the study.

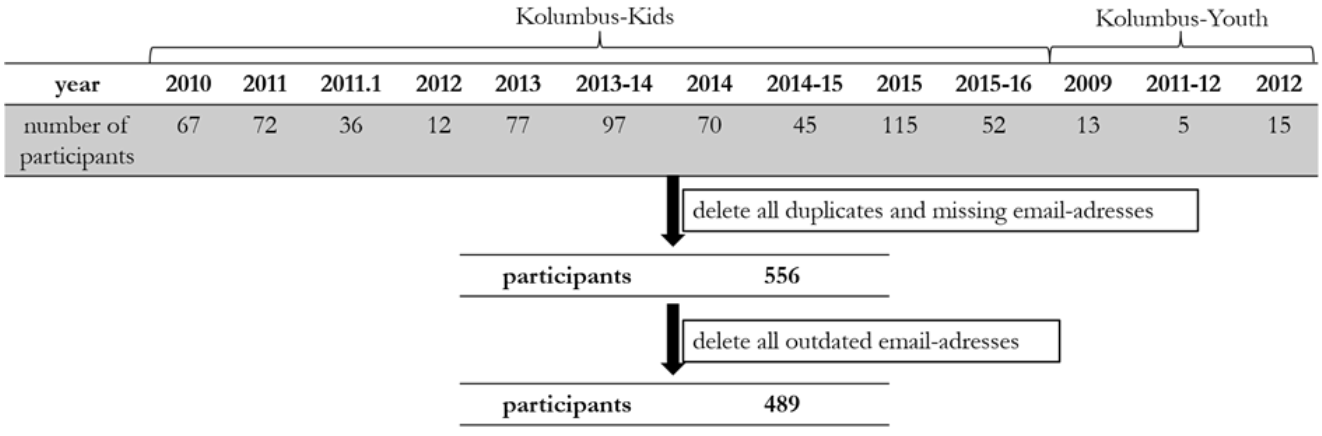


**Figure 3.**

*Composition Overview of the Utilized Sample*

### Test Instrument

An online-questionnaire was used which consisted of a brief introduction, in which the participants are presented with an explanation and general conditions of the study, addressing data protection regulations. To participate, students were required to place a digital checkmark next to the data protection guidelines. Personal data such as age, gender, years of participation (e.g., entry year and exit year) in project "Kolumbus-Kids" and information regarding the school course preferences (e.g., course choices, advanced courses, etc.) and potential current employment (e.g., career path) were collected. The next section evaluated the subjective former experience in project "Kolumbus-Kids". The questionnaire contained a total of 36 items from six different constructs, where each item is rated on a 6-point Likert scale (1 = does not apply at all; 6 = applies fully). To ensure that the items were limited to one particular construct, each item was constructed upon a theoretical basis. Special care was taken to ensure that all items fully represented each individual construct (Eid & Schmidt, 2014). Items from the constructs *Retrospective interest* and *Current, scientific self-concept* were adapted for this study from existing constructs, and items pertaining to *Influence on the choice of career and/or course* were independently derived (see Table 2).

**Table 2.**

*Presentation of the Constructs Relevant for the Pilot Study with the Corresponding Authors and an Example Item*

| Construct | Author | Example item |
|---|---|---|
| *Retrospective interest* | Wegner, 2009 | Item 1: It was only through the project "Kolumbus-Kids" that I realized that I have a keen interest in scientific phenomena and experiments. |
| *Current, scientific self-concept* | Pawek, 2009<br>Wegner, 2009 | Item 10: Since attending project "Kolumbus-Kids", observations in my daily life have often led me to think of questions that could be clarified through an experiment. |
| *Influence on the choice of career and/or course* | This study, 2019 | Item 35: Because of my participation in project "Kolumbus-Kids" I can now imagine pursuing a career in a scientific field. |

## Results

We hypothesized that project participants would have similar levels of interest in natural sciences, similar scientific self-concepts and attribute a similar level of influence, concerning their career path and/or course choice, to project "Kolumbus-Kids". Although 72.7% of the participants were still attending secondary school (i.e., were not yet sure of their future career plans), 60.0% of the participants already graduated secondary school were either in a STEM-related degree program or working in a STEM- related profession. When compared to the national German averge, particpants that took part in "Kolumbus-Kids" participants were more than three time likelier to pursue a career in a STEM-related profession (see Figure 4).

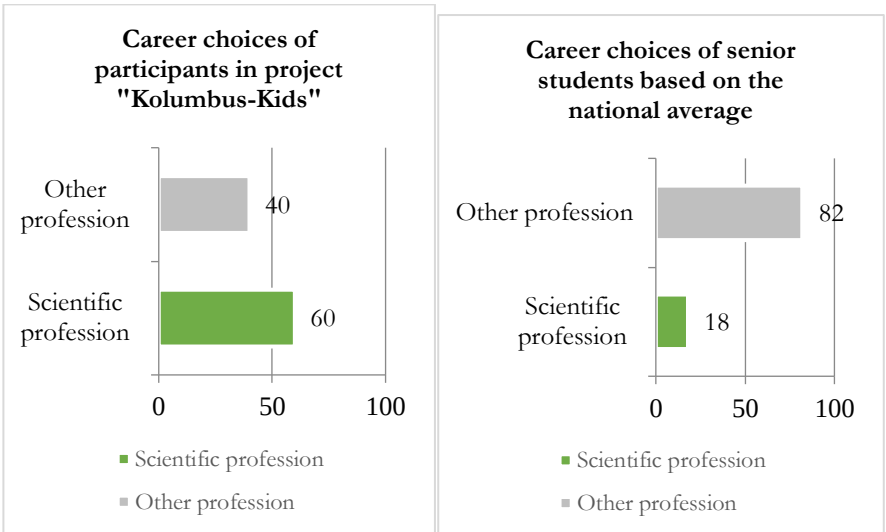


**Figure 4.**

*Comparison between Participants in Project and the National Average of High School Graduates*

We found no gender differences in retrospective interest (male: $M$ = 4.79, $SD$ = 0.61; female: $M$ = 4.81, $SD$ =0.93; $t(135)$ = 0.17, $p$ = .869), scientific self-concept (male: $M$ = 4.87, $SD$ = 0.58; female: $M$ = 4.77, $SD$ =0.65; $t(135)$ = 0.92, $p$ = .357) or the influence that the project "Kolumbus-Kids" had on their career choice (male: M = 4.57, SD = 0.78; female: M = 4.54, SD = 0.96; $t(135)$ = 0.19, $p$ = .853; see Table 3).

**Table 3.**

*Mean, Standard deviation, and Statistical Significance (p-value) of Male and Female Participants for the Constructs*

| Construct | Gender | *N* | *M* | *SD* | Sig. (2-sided) |
|---|---|---|---|---|---|
| *Retrospective interest* | Male | 68 | 4.79 | 0.61 | .869 |
| | Female | 69 | 4.82 | 0.93 | |
| *Current, scientific self-concept* | Male | 68 | 4.87 | 0.58 | .357 |
| | Female | 69 | 4.76 | 0.65 | |
| *Influence on the choice of career and/or course* | Male | 68 | 4.57 | 0.78 | .853 |
| | Female | 69 | 4.54 | 0.96 | |

## Discussion and Conclusion

The project "Kolumbus-Kids" successfully strengthens and stabilitizes scientific self-concepts for the long-term (male: M = 4.87 (SD = 0.58); female: M = 4.77 (SD =0.65, see Table 3). On the one hand, this may result from the practical and hands-on oriented design of the project sessions, where participants view themselves as young "active scientists" (Wegner, 2013). They are provided with an environment to develop an inclination for subject-specific content and experience positive emotions by conducting experiments (Wegner, 2009). On the other hand, the wide range of topics covered by the project provides participants with detailed insights into many STEM-related fields and allows them to experience the versatility of natural sciences and address interdisciplinary overlaps (Wegner, 2013; see Figure 2). In the project "Kolumbus-Kids", participants are given the opportunity to identify themselves in a web of interweaving topics, while consistently pursuing their individual interests.

Oftentimes, it is apparent that interest acts as a decisive factor when it comes to learning success, motivation and career decisions (Schiefele et al. 1993). Consequently, interest also acts as a prerequisite for major decisions, such as deciding in favor of a particular educational and/or career path. We found no significant gender-differences and notably that interest in former female participants is slightly higher than male participants, which leads us to conclude that our project develops, promotes and sustainably establishes interest in the natural sciences, regardless of gender. In comparison to studies with one-day school laboratories (Guderian, 2005; Hausamann, 2012), our study shows that the overall interest in natural sciences in "Kolumbus-Kids" produces long-term effects. Through the relatively high mean values perceived for the construct of retrospective interest, it can be assumed that the former participants also show a high level of subject-specific interest pertaining to natural science.

We did not find a gender difference in the construct *Influence on the choice of career and/or course* in the project "Kolumbus-Kids", suggesting that all participants are supported equally and attribute a similar amount of the project's influence to their respective course choices or career paths. Notably, the overall influence of the project is rated positively. The project "Kolumbus-Kids" provides these individuals with insights into the working methods and processes in the field of natural sciences and furthermore enables them with the opportunity to explore potential STEM-related fields before making decisions about their future. As gifted individuals typically have versatile talents and interests in different disciplines, a wide range of realistic career paths (i.e., or potential school courses) are available to them (Holling & Kanning, 1999). These results can be used to evaluate the long-term sustainability of the project, even after the courses have been completed.

Although the enrichment project improves scientific interest, scientific self-concept and exerts an influence on future career paths, our results should be interpreted with caution. When assessing the results, we have to evaluate the sample of the study. With regard to the time of participation and survey, the response rate (28.4%) can be rated as

acceptable. However, the question rises whether only interested and pupils that benefit participated in the survey. Efforts should be made to increase the sample size. The study only evaluated a homogeneous group of high-performing students and young adults (i.e., selected based on an entrance test and intelligence quotient). Therefore, conclusions are not transferable to heterogeneous student populations. A further limitation is that we had no control group; potential control groups for future investigations could include former students who either expressed interest in participating in the project, but were not selected to participate (e.g., based on a low-scoring entrance exam) or former students who did not express an increased interest in natural sciences during their normal school lessons. Only through a comparison with a control group can valid statements be made about the level of the mean values and thus the overall effectiveness of the program. During the analysis of the data, it turned out that some further optimization of the test instrument is advisable. Since this is a pilot test, some changes to the formulating of items and small modifications were expectable. Furthermore, the questionnaire could be enhanced to include more constructs or include qualitative elements, such as conducting interviews or organizing group discussions, which could ultimately lead to a more in-depth assessment of reasons and motivations. Finally, survey students prior to project participation, which would enable the ability to measure and track various changes of them over time (i.e., longitudinally). In addition, the survey must be repeated at regular intervals, maybe every few years, to check how long-term effects change over time for the individual.

Using quantitative, longitudinal biographical research of gifted individuals can provide additional insight concerning the effectiveness of our enrichment-program. In further studies, these test results can be linked to the topics that the participants have dealt with in their courses. It can be examined whether different topics also produce different outcomes. Finally, the quantitative study can be supplemented by qualitative surveys to gain some information about reasons for participation and some useful facts for interpretation.

## Acknowledgement

The authors would like to thank Vivienne Litzke for constructive criticism and language editing of the manuscript.

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