How Do German Science Teachers Characterize Biological Giftedness?

Anke Renger[1], Julia Schwanewedel[2]

University Hamburg, Germany[1,2]

Abstract

In 2016, a joint initiative of Germany's federal government and Germany's federal states called "LemaS" (meaning something like 'students' performance sets a precedent') started. The aim of this initiative is to foster high-achieving and potentially gifted students in regular school lessons [1]. One of the 22 sub-projects focusses on STEM – biology education and empirically investigates what characterizes biology-related giftedness. The overall aim of the sub-project is to develop a diagnostic-tool for biological giftedness and conveying tools.

Previous talent models (e.g. Gagné [2]) are not subject-specific, so they do not refer to biology or biological giftedness. However, studies have shown that giftedness is subject-specific. Therefore, a specialist description is required. To find out what characterizes biological giftedness, teaching experts (N=70), i.e. biology teachers from participating schools, take part in an online survey including open questions on general and subject-specific giftedness and relating to the German federal educational STEM-standards [3]. The 2nd part evaluates whether teaching experts see these standards as indicators of biology-related talent. Survey data were analysed using qualitative content analysis and (descriptive) statistics.

Data of the two-part questionnaire regarding (1) the characterization of biological giftedness show that almost all survey participants see interest and the basic understanding of biological relationships are important factors for giftedness. (2) Furthermore, data of the 2nd part show that the German federal educational standards in biology can partly be used as indicators for biological giftedness

The results show in addition to general characteristics also subject-specific characteristics of biology-related giftedness. The results can provide guidance on additions and differentiation for Gagné's talent [2] model for biology-related talent. Based on such an expanded model, diagnostics and support instruments for teaching can be developed and examined for their effectiveness.

Keywords: *giftedness, teacher, Germany, science education, biology.*

1. Theoretical backround

The concept of giftedness has changed considerably in recent years [4]. Whereas in the past it often referred to cognitive performance aspects, today it is viewed much more broadly from a multi-perspective point of view [2]. The aim of gifted education is therefore to provide optimal support for the development of potential in children and adolescents [1]. This form of giftedness promotion up to talent or excellence promotion has already been successfully practiced in sports for decades [5]. In the natural sciences and technology this systematization of talent identification and development can still be expanded.

A systematic talent identification and development starts in regular lessons at school. This aspect is addressed by the German project LemaS. LemaS is a research and development project funded by the German Federal Ministry of Education and Research to promote high-performing and potentially high-achieving students. Research shows that these students have individually different subject-specific potentials and needs, and they differ greatly in their personal development [6]. Since teachers often lack the appropriate concepts to (better) pay attention to these students [7] [8], individual and diagnosis-based support for these students has so far rarely taken place in school practice. Studies show, however, that a good match between the individual learning starting situation and the respective teaching offer is an indispensable prerequisite for exploiting performance potential [9]. Thus, it is necessary to develop adaptive diagnosis-based support concepts that can be adapted to daily school practice and that take the complex set of conditions into account.

The present LemaS subproject STEM-biology focuses on biology education and is oriented towards Gagnés differentiated model of giftedness and talent [2]. This model focuses on the importance of the pedagogical learning environment and different didactic support options. Furthermore, this model strongly emphasizes the processual character in talent development. Teachers play a crucial role in providing (learning) opportunities and learning spaces. This is where the MINT-Bio sub-project wants to start and focus on the learning space in particular.

2. Present study

Existing models of giftedness [10] [11] still lack a biology-specific dimension. However, studies have shown that giftedness is subject-specific. For an optimal support of gifted students in the regular biology classroom it is therefore necessary to clarify first:

1. What basic understanding do experienced biology teachers have of giftedness in general and of biology-related giftedness in particular?
2. How do experienced biology teachers characterize successful biologically gifted students and successful biologically professionals?
3. What role do experienced biology teachers attribute to the variables interest and motivation with respect to the development of potential of biologically gifted students?
4. Which subject-related competencies (federal educational standards) of students do teachers see as indicators for biology-related giftedness?

This article focuses on question 1 and 4.

3. Method

3.1. Participants

The sample consisted of 35 (1st part) and 23 (2nd part) secondary school biology teachers of 70 invited biology teachers among ten schools involved in the STEM-biology subproject, of whom the majority was female (67%). All teachers met the following criteria: (1) degree in biology; (2) teaching biology or natural science subjects; (3) at least 3 years of professional experience.

3.2. Procedure

To answer the research questions, an anonymous online survey was conducted among ten schools involved in the STEM-biology subproject. Based on established criteria (see above), a total of n=70 teachers received a letter of invitation to participate in the study. Of these, 35 (1st part) and 23 (2nd part) responded, respectively, and were included in the study. The letter included an Internet link to the online survey. Participation was voluntary.

3.3. Instruments

The respondents completed a two-part questionnaire. The first part included seven open-ended questions about the perspective of biology teachers related to general and biological giftedness.
The second part was related to the German federal educational standards in biology, which were assessed by the participants using a 6-point Likert scale (6 = very strong, 1 = not at all) to the question: *How strongly do you see this item as an indicator of the overall construct of biology-related giftedness?* And the end of the survey different background information was requested. It took approximately 30 to 60 minutes to answer the questionnaire.

3.4. Analysis

This survey is subject to the mixed-method approach, meaning that both elements of qualitative and quantitative analysis are used for analysis. Data of the first part were analyzed using qualitative content analysis with MAXqda. The purpose of qualitative content analysis is to make replicable and valid inferences from a text [12]. The analysis was carried out in an inductive-oriented manner as all the codes were derived from the data. The purpose was to capture biology teachers' perspectives on (biological) giftedness.
The data of the second part were analyzed quantitatively with PRISM. First, a descriptive data analysis was performed to calculate the mean, median and mode values as well as the standard deviation. As a second step, the items were ranked according to the highest agreement within the four areas competences of the federal educational standards in biology (subject knowledge, scientific inquiry, scientific communication, decision-making on SSIs).

4. Results

Qualitative Content analysis for the first survey part resulted in a total of four main categories with 2-8 subcategories for the question on biology-related giftedness. Some of these are shown as examples in Table 1. It can be seen that interest (4) and the basic understanding of biological relationships (1) are important factors for giftedness. In addition, the biology teachers mention the networked and independent thinking of learners (3) as well as the urge to learn more and to work determinedly on it (2) as other important factors for giftedness.

Table 1: Selected categories identified for biological giftedness (initial coding) (n=23)

main categories and (selected) subcategories	Frequency	Description - biology-related giftedness …	Example
1. Understanding biology-related giftedness - biology-related giftedness requires (special) understanding of biological relationships	9	… requires a basic understanding of biology	"A biologically gifted person wants to understand how living beings live, why certain structures exist, whether what is known is already the end of knowledge, etc."
2. biology-related personality traits - perseverance	3	… is explained in connection with perseverance	"…with a special understanding of biological interrelationships and the corresponding urge to want to learn more about a subject…"
3. biology-related skills and abilities (competencies) - scientific thinking	5	… is explained in connection with scientific thinking (posing questions, forming hypotheses and testing them, transfer performance)	"to recognise scientific (especially biological) facts or problems and to work on and solve them as independently as possible in a relatively open (research-developing) concept and solve them"
4. interest and attitude - interest	14	… is explained in connection with interest	"interest in gaining scientific knowledge in order to better understand/test/evaluate phenomena, correlations, observations, hypotheses, etc."

In the 2nd part, the biology teachers were asked to rate how strongly they consider standards of the German federal educational standards in biology as an indicator of the overall construct of biology-related giftedness (Table 2). Table 2 shows the 12 educational standards that the biology teachers from the sample see as the most appropriate indicators of biological giftedness.

Table 2: Assess the suitability of the German federal educational standards in biology as indicators of biological giftedness.

competence area	High agreement (> 43%) with the listed items as indicators for biological giftedness School students ...	Proportion in the sample (n=23)	median
Decision-making	B7 discuss options for action for environmentally and nature-friendly participation in terms of sustainability	66.7 %	6
Decision-making	B6 evaluate the influence of global cycles and material flows under the aspect of sustainable development	66.7 %	6
Decision-making	B5 describe and assess the effects of human interventions in an ecosystem	66.7 %	6
Scientific Inquiry	E7 apply steps from the experimental way of gaining knowledge to explanation	61.1 %	6
Scientific Inquiry	E8 discuss the scope and limitations of the research design, steps and results	55.6 %	6
Scientific Inquiry	E10 analyse interactions with the help of models	55.6 %	6
Scientific Inquiry	E6 plan simple experiments, carry out the experiments and/or evaluate them.	55.6 %	6
Decision-making	B3 describe and evaluate findings and methods in selected current references such as to medicine, biotechnology and genetic engineering, taking into account socially negotiable values	55.6 %	6
Scientific communication	K4 evaluate information on biological issues from various sources in a targeted manner and process this information using various techniques and methods in an appropriate way for the target group and situation.	50.0 %	5.5
Decision-making	B2 evaluate different measures and behaviours to preserve one's own health and to be socially responsible	50.0 %	5.5
subject knowledge	F3.8 know and discuss human interventions in nature and criteria for such decisions.	43.5 %	5
subject knowledge	F2.6 describe and explain the adaptation of selected organisms to the environment.	43.5 %	5

5. Discussion

Results of the qualitative content analysis of the first part of the online survey show that the biology teachers consider, among other things, interest in biological contents as an important prerequisite for giftedness. In addition, the respondents distinguish between subject-specific characteristics, e.g. diversity of topics and the presence of cognitive skills, as well as process-oriented competences aiming at scientific thinking and inquiry.

Analysis of the 2nd part of the survey shows that the German federal educational standards in biology can be used in part as indicators for biological giftedness. It is particularly striking that among the standards considered most appropriate as indicators of giftedness, process-related competencies are primarily reported. Above all, biology teachers evaluate standards from the competency area of decison-making as indicators of biological giftedness. These results are interesting in the context of other research on science giftedness - for example, Pekore and Demitrikopoulos (2015) also emphasize the prominent role of process-related skills like creating, anaylzing and evaluating for scientific giftedness.

Further analyses should provide information on which concrete competencies of the educational standards in biology the teachers refer to in their open answers and which commonalities, differences and peculiarities exist with regard to general models of giftedness [2][10][11].Overall, the results may help to inform approaches to identifying and promoting biological giftedness away from special enrichment programs in regular classrooms as well [13].

References

[1] iPEGE (International Panel of Experts for Gifted Education). (2009). Professional Promotion of the Gifted and Talented: Recommendations for the qualification of experts in gifted education.
[2] Gagné, F. (1993). Constructs and models pertaining to exceptional human abilities. In: K. A. Heller, F. J. Mönks & A. H. Passow (Eds.). *International Handbook of Research and Development of Giftedness and Talent* (69 – 87). Oxford: Pergamon.
[3] KMK (2005). Bildungsstandards im Fach Biologie für den Mittleren Schulabschluss. München 2005. München: Luchterhand. https://www.kmk.org/fileadmin/Dateien/veroeffentlichungen_beschluesse/2004/2004_12_16-Bildungsstandards-Biologie.pdf (abgerufen am: 31.03.2021)
[4] Ziegler, A., & Heller, K. A. (2000). Conceptions of giftedness from a meta-theoretical perspective. *International handbook of giftedness and talent*, *2*, 3-21.
[5] Baker, J., Cobley, S., Schorer, J., & Wattie, N. (Eds.). (2017). *Routledge handbook of talent identification and development in sport*. Taylor & Francis.
[6] Souvignier, E., Philipp, M. (2016). Implementation–Begrifflichkeiten, Befunde und Herausforderungen. *Implementation von Leseförderma*ß*nahmen. Perspektiven auf Gelingensbedingungen und Hindernisse,* S. 9-22.
[7] Sjuts, B. (2017). *Mathematisch begabte Fünft-und Sechstklässler: theoretische Grundlegung und empirische Untersuchungen*. WTM, Verlag für wissenschaftliche Texte und Medien.
[8] Heller, K. A. (2005). Education and counseling of the gifted and talented in Germany. *International Journal for the Advancement of Counselling*, *27*(2), 191-210.
[9] Connor, C. M., Morrison, F. J., Fishman, B. J., Schatschneider, C. & Underwood, P. (2007). Algorithm-guided individualized reading instruction. *Science, 315*, 464-465.
[10] Renzulli, J. S. (1979). *What Makes Giftedness?: A Reexamination of the Definition of the Gifted and Talented*. Ventura County Superintendent of Schools Office.
[11] Heller, K. A., Perleth, C., & Lim, T. K. (2005). The Munich model of giftedness designed to identify and promote gifted students. *Conceptions of giftedness*, *2*, 147-170.
[12] Mayring, P. (2004). Qualitative content analysis. *A companion to qualitative research*, *1*(2), 159-176.
[13] Heyder, A., Bergold, S., & Steinmayr, R. (2018). Teachers' knowledge about intellectual giftedness: A first look at levels and correlates. *Psychology Learning & Teaching*, *17*(1), 27-44.