General and Physics-Specific Mindsets about Intelligence and Giftedness: A Study of Gifted Finnish Upper-Secondary-School Students and Physics Teachers

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Abstract

A key factor in supporting talent development among gifted students is the fostering of a growth mindset in their learning. However, there has been little research on the subject-specific mindsets of these students and their teachers. This study examined the mindsets of academically gifted Finnish upper-secondary students (N = 164) and Finnish physics teachers (N = 131) concerning overall and physics-specific intelligence and giftedness. A quantitative approach was used, the data being collected through online questionnaires. The mindsets of both students and teachers were more malleable with regard to intelligence than to giftedness, but with regard to giftedness the teachers' mindsets were more malleable than those of their students. Gender- and grade-level-related differences were found among the students. Among the teachers, variances related to teaching experience, those with the least experience having the most malleable mindsets. The students had similar general and physics-specific mindsets, whereas the teachers' physics-specific beliefs were more malleable than their general beliefs. The mindsets of the gifted students were not particularly growth-oriented, indicating that encouraging malleability may help them to reach their full potential. The results also highlight the need to distinguish between the terms intelligence and giftedness in research on mindsets.

Keywords: Mindset; intelligence; giftedness; upper-secondary students; physics teachers.

The focus of this study was on mindsets, also referred to as implicit beliefs, about intelligence and giftedness. In particular, we were interested in the general and physics-specific mindsets of physics teachers and their gifted students. Although science, technology, engineering and mathematics (STEM) skills are acknowledged as critical factors for innovation and growth in knowledge-intensive societies (Office of Innovation and Improvement, 2016), persistence in studying STEM subjects is not self-evident, even among science-oriented high-ability students (Webb, Lubinski, & Benbow, 2002). Many of these students face barriers such as the avoidance of challenges, underachievement, and an inability to manage when suffering setbacks (Subotnik, Olszewski-Kubilius, & Worrell, 2011). Contrary to the common misconception, gifted students do not automatically excel, but may need different types of support in their learning (Yeung, 2012).

A major factor in fostering creative thinking, overall wellbeing and the challenging of gifted students is to educate them and their teachers in the development of a growth mindset in relation to learning (Tirri, 2016). Mindsets are implicit beliefs held by individuals about their fundamental characteristics and abilities (Dweck, 2000; Dweck, 2006). According to the implicit theory of intelligence (Dweck, Chiu, & Hong, 1995), people believe that intelligence is either malleable (incremental theory) and thus can be developed, or static (entity theory) and thus not open to improvement. Dweck (2006) later referred to these alternatives as a "growth mindset" and a "fixed mindset", respectively. Beliefs about intelligence shape an individual's response to academic challenge (Dweck, 2000; Dweck & Leggett, 1988: see Table 1). Even if both types of individual have equal intellectual ability, those viewing intelligence as an inborn and stable quality tend to withdraw when facing a challenge exceeding their assumed level of ability. They also prefer performance goals and see tasks as competence tests. Consequently, a fixed mindset may lead to the avoidance of challenges and vulnerability to negative feedback. On the other hand, those endorsing a growth-oriented view place more emphasis on learning goals, seeing a challenge as an opportunity to improve their competence.

Table 1: Features of the two mindsets about intelligence.

Feature	Growth mindset	Fixed mindset
Orientation to challenge	Chance to improve competence	Threat Competence test
Response to challenge	Spending effort Striving to develop	Withdrawal Avoidance
Achievement goal	Learning "Becoming smart"	Performing "Looking smart"
Facing setbacks/negative feedback	Learning from mistakes	Fear of failure

Currently, there is no consensus among scholars concerning the definitions of giftedness and intelligence. Nevertheless, it is recognized in established theories (e.g. Gagné, 2010; Gardner, 1999; Reis & Renzulli, 2009; Subotnik et al., 2011) that giftedness is developmental, meaning that individuals are able to develop their potential through appropriate training (Gagné, 2010). This development is also assumed to be influenced by personal variables such as mindset and motivation (Dweck, 2006; Subotnik et al., 2011). The models also posit that giftedness may manifest unevenly in different domains (Gagné, 2010; Subotnik et al., 2011), and is thus not the same as a high overall IQ. Domain-specificity is well-represented in Gardner's (1999) theory, which emphasizes the problem-solving nature of intelligence and lists eight different types. According to Subotnik et al. (2011), gifted persons demonstrate top-of-the-scale performance even when compared to other high-performing individuals. Gagné (2010) states more specifically that individuals in the top 10 percent of their age group in at least one ability domain could be considered gifted.

Researchers continue to debate on whether individuals' mindsets about intelligence are consistent across academic domains (Martin, Bostwick, Collie, & Tarbetsky, 2017). Physics is usually grouped with other subjects or domain categories such as "STEM subjects", or "quantitative" or "hard" sciences in domain-specific mindset-related studies, and in some cases it is paired with mathematics. Very few studies on mindsets focus exclusively on physics. However, research on higher education in physics, among both students and faculty members, reveals a tendency for a fixed mindset to be associated with talent and success (Leslie, Cimpian, Meyer, & Freeland, 2015; Scherr, Plisch, Gray, Potvin, & Hodapp, 2017). However, the link between mindset and achievement in quantitative subjects might not be as clear as previously thought. As Kuusisto, Laine and Tirri (2017) found in their study among students in elementary and secondary school, fixed beliefs about giftedness but malleable views about intelligence indicated higher grades in mathematics.

Previous studies have also revealed gender differences. A growth-oriented view on math-specific intelligence was found to indicate better learning outcomes among females than males in upper-secondary education (Degol, Wang, Zhang, & Allerton, 2018). It has also been reported that female college students who perceived their learning environment as endorsing growth ideas about math intelligence were likely to preserve a sense of belonging to the subject, even in an environment with a high degree of gender stereotyping (Good, Rattan, & Dweck, 2012). This, in turn, had a positive impact on their achievement and academic choices, whereas among males the link between a fixed mindset and gender stereotyping did not predict a sense of belonging to math. Broome (2001) reported similar findings related to physics. His study among lower-secondary-level students revealed that females with malleable views on physics-specific intelligence rated their problem-solving abilities more highly than females with fixed beliefs, whereas among males the result was the opposite. On the basis of these findings, researchers emphasize the importance of promoting a growth mindset in math- and physics-specific intelligence to increase females' participation in STEM subjects.

According to Dweck (2000), students identified as gifted may be more prone to developing fixed mindsets. However, Mofield and Parker Peters (2018) found no difference in mindsets about intelligence between gifted and average students in middle school. Esparza, Shumow, and Schmidt (2014) also compared intelligence-related science-specific mindsets among gifted and average seventh-grade students, reporting that gifted students had more malleable beliefs. Likewise, gifted 9–17-year-old summer-school students in Feldhusen and Dai's (1997) study held growth-oriented views on their abilities, although the words ability, gift, and talent were used instead of the term intelligence. Snyder, Barger, Wormington, Schwartz-Bloom, and Linnenbrink-Garcia (2013), in turn, showed that labeling high-ability college students as gifted was modestly related to their adopting a fixed mindset about intelligence. Makel, Snyder, Thomas, Malone, and Putallaz (2015) further highlight the need for a clear distinction between intelligence and giftedness as concepts. They found that gifted students understood intelligence and giftedness as being connected, yet many perceived intelligence as malleable and giftedness as stable, rarely the opposite.

Previous research has established the essential nature of the teachers' role in identifying and meeting the needs of gifted students. These students need to be challenged (Reis & Renzulli, 2009) and taught how to motivate themselves to deal with difficult situations (Balduf, 2009). Teachers also have a role in conveying the growth-oriented view of learning to their students (Dweck, 2006). Their mindsets affect their behaviors and pedagogical choices in terms of how they praise their students and deal with failures (Dweck, 2006), and how they introduce new topics and design classroom activities (Davis & Sumara, 2012). Teachers with a malleable view of intelligence prefer open-ended assignments that foster creative learning, for example, whereas those with an entity view tend to favor closed-ended tasks that do not offer growth-oriented feedback (DeLuca, Coombs, & LaPointe-McEwan, 2019). Mindsets are also closely connected to approaches to student assessment (DeLuca et al., 2019).

Studies on the association between teachers' mindsets and teaching domains have produced mixed results. Laine, Kuusisto, and Tirri (2016) found in their study of Finnish teachers' conceptions of giftedness that 54 percent of the teachers had a growth mindset, 30 percent had a fixed mindset, and among the remaining 16 percent the mindset was mixed. They observed no differences between teachers of different subjects. De Kraker-Pauw, Van Wesel, Krabbendam, and Van Atteveldt (2017), in turn, found no association between the teaching subjects and the mindset-related assessment orientation of Dutch teachers. However, they did observe that STEM teachers gave a higher proportion of growth-oriented feedback than non-STEM teachers. In contrast, Jonsson, Beach, Korp, and Erlandson (2012), reported that teachers of the Swedish language and of social science favored a growth over a fixed mindset about intelligence, thereby differing from STEM teachers among whom no such difference was observed.

Research on mindsets across different domains, especially physics, remains limited. We aim to narrow this gap by exploring how gifted students and their teachers view the nature of intelligence and giftedness in general, and specifically in physics. Our research question is as follows:

> What overall and physics-specific mindsets about intelligence and giftedness prevail among gifted students in Finnish upper-secondary education and their physics teachers?

The context of the study

This study was conducted in the context of Finnish upper-secondary school, which provides general academic education typically for 16–19-year-olds, most students graduating in three years. Over the last twenty years, females have comprised more than half of these students, the 2018 ratio being 58 percent (Statistics Finland, 2019). Gifted students have not been a priority in Finnish educational policy or in schools' teaching practices, despite the increasing tendency toward individuality (Tirri & Kuusisto, 2013). Moreover, there are no definitions of giftedness, and no identification criteria.

The selection of students for upper-secondary school is based on their grade point average (GPA) for the theoretical subjects in the basic education certificate. Although there is no official differentiation between schools for gifted and ordinary students, certain upper-secondary schools tend to attract high achievers, and they also require a high GPA for admission (Tervonen, Kortelainen, & Kanninen, 2017). Nevertheless, there are no significant differences in the quality of teaching between the various schools (Tirri & Kuusisto, 2013): high-performing students score equally well in the matriculation examination regardless of the school they attended, for instance (Tervonen et al., 2017). The Finnish national matriculation examination, a biannual series of final tests in several subjects, has an important role in guiding studies in upper-secondary education. The purpose is to evaluate how well students have assimilated the knowledge and skills required by the curriculum and whether they have reached an adequate level of maturity (Matriculation Examination Board, 2020a). It is also used as an entrance examination for third-cycle studies.

We identified the students participating in this study as academically gifted based on their top-of-the-scale performance (Gagné, 2010; Subotnik et al., 2011). The student data for this study was collected in a single school with an exceptionally high GPA requirement for admission, consistently among the highest of all general upper-secondary schools in Finland (Ministry of Education and Culture & Finnish National Agency for Education, 2019). In 2017–2019 the lowest GPAs allowing admission to this school ranged from 9.2 to 9.6 on a scale from 4 (*fail*) to 10 (*excellent*). Second, students from this school tend to achieve very high scores in the matriculation examination: in spring 2019, for example, 73 percent of those matriculating with a grade in physics achieved one of the two highest scores in the subject, against the 31-percent national average (Matriculation Examination Board, 2020b). The overall scores fell within the top five among all 401 Finnish schools offering upper-secondary education (Matriculation Examination Board, 2020b; Natri, Salminen, Ekholm, West, & Lång, 2019).

Teachers in Finland are trained to differentiate their teaching to consider the individual needs of students, yet there are no mandatory courses for teachers focusing on giftedness (Laine, Kuusisto, & Tirri, 2016). Physics teachers, as subject teachers, are qualified to teach on both lower- and upper-secondary levels. Subject teachers in Finland are required to have a Master's degree in their teaching subject(s), and the education also includes pedagogical studies and guided teaching practice. STEM teachers typically specialize in a major and a minor subject, a common combination being mathematics and physics.

Data and methods

Participants

The student data was collected in a single school. Students (N = 164) recognized as gifted responded anonymously to an online questionnaire as part of their physics lesson under the supervision of their teacher. Consent for participation was received from the students, their guardians, and the administrative principal of the school. Most of the respondents identified themselves as either female (n = 102, 62%) or male (n = 59, 36%). In the Finnish education system, students enter the upper-secondary level at the age of 15–16 (first grade). Hence, second-graders are aged 16-17, third-graders 17–18, and fourth-graders 18–19 in the beginning of the school year, which was the time of the data collection. Sixty-two (38%) students were in the first grade of upper-secondary school, 52 (32%) in the second grade, and 50 (30%) in the third or fourth grade. From the original sample of 179 respondents, 15 were removed based on information that they were not continuing to study physics. Thus, all the students in the final sample had selected to study physics beyond the single mandatory course. At the time of their participation the first-graders had completed only one physics course, the second-graders from three to four courses, and the third- and fourth-graders from seven to eight. The mean grade-point-average score in physics was 8.80 (SD = 0.80) on a scale ranging from 4 (*fail*) to 10 (*excellent*). The course grades were based on the teachers' assessment of course work and non-standardized test results.

The teachers (N = 131) were contacted through various regional and national science-teacher networks and were asked to complete an online questionnaire anonymously. Fifty-eight (44%) of the respondents identified themselves as females and 68 (52%) as males. Physics was a major subject among 71 (54%) of them. It was a minor subject among the rest (n = 60, 46%), the major typically being mathematics or chemistry. Three teachers with mathematics as their major also had a secondary major in physics.

The sample included teachers with a wide range of experience in teaching physics, the categories being less than one year (n = 5, 4%), from 1 to 5 years (n = 31; 23.5%), from 6 to 10 years (n = 26, 20%), from 11 to 15 years (n = 31; 23.5%), from 16 to 20 years (n = 6, 5%), and 21 years or more (n = 32, 24%). The majority of the respondents had accumulated most of their physics-teaching experience in upper-secondary (n = 54, 41%) or lower-secondary (n = 45, 34%) schools, or a combination of the two (n = 18, 14 %). The rest (n = 14, 11%) gained most of their experience on the vocational or university level.

Instrument

We utilized Dweck's instrument to investigate the beliefs of students and teachers about the overall nature of intelligence and giftedness. Dweck's instrument is a frequently used, originally 8-item self-report scale measuring fixed and growth mindsets about intelligence (Dweck, 2000, pp. 177–178). The instrument uses the following scores: 1 (*strongly agree*), 2 (*agree*), 3 (*mostly agree*), 4 (*mostly disagree*), 5 (*disagree*), and 6 (*strongly disagree*). We expanded the instrument with the physics-specific counterparts of the original items. We used four sets of four statements addressing overall and physics-specific intelligence as well as overall and physics-specific giftedness (Table 2). The participants indicated their attitude towards the statements on the previously mentioned 6-point Likert scale, the lower scores corresponding to a more fixed mindset.

With regard to the teachers, background information was collected on gender, teaching experience, major subject, and the school level of which they had the most experience, whereas the students were asked about their gender, grade level and whether they were going to continue studying physics in upper-secondary school. Grade point averages in physics were computed from the school's student record system.

Results

Students

Statistical analyses were conducted in several phases using SPSS version 25. A principal component analysis (PCA) was carried out to see if the items differed from each other. We had hypothesized that the components would correlate, hence we used a direct oblimin for oblique rotation. The Kaiser-Meyer-Olkin measure, KMO = .902, indicated a very good level (De Vaus, 2002) of sampling adequacy for the PCA. The Bartlett's test of sphericity was significant (p = .000), verifying that we could carry out the analysis.

The data revealed two components with eigenvalues exceeding Kaiser's criterion of 1, explaining 79.28 percent of the variance. The first component consisted of both general and physics-specific items related to giftedness, and the second one comprised both overall and physics-specific items about intelligence (Table 2). The Cronbach's alpha (1984) for the eight giftedness items was 0.972, and for the eight intelligence items it was 0.949, both indicating an acceptable level of internal consistency. Paired samples t-tests revealed no statistically significant differences between the overall and the physics-related items in either component.

Table 2: Items, means, component loadings, communalities (h^2), Cronbach's Alphas, and percentages of variance in the student sample ($N = 164$).

Item	*M* (SD)*	Comp. 1	Comp. 2	h^2
Mindset about intelligence	4.25 (0.95) α = .949			
General	4.24 (0.97)			
1. You have a certain amount of intelligence, and you really cannot do much to change it.	4.36 (1.03)	.06	.82	.71
2. Your intelligence is something about you that you cannot change very much.	4.12 (1.10)	–.05	.86	.70
3. To be honest, you cannot really change how intelligent you are.	4.45 (1.06)	–.12	.89	.73
4. You can learn new things, but you cannot really change your basic intelligence.	4.02 (1.12)	.05	.85	.76
Physics-specific	4.25 (1.04)			
5. You have a certain amount of intelligence in physics, and you really cannot do much to change it.	4.30 (1.09)	.06	.86	.77
6. Your intelligence in physics is something about you that you cannot change very much.	4.16 (1.06)	.03	.88	.80
7. To be honest, you cannot really change how intelligent you are in physics.	4.42 (1.13)	.00	.88	.78
8. You can learn new things in physics, but you cannot really change your basic intelligence in physics.	4.14 (1.23)	.05	.83	.71
Mindset about giftedness	3.54 (1.27) α = .972			
General	3.54 (1.36)			
9. You have a certain amount of giftedness, and you really cannot do much to change it.	3.65 (1.38)	.92	–.05	.82
10. Your giftedness is something about you that you cannot change very much.	3.46 (1.41)	.96	–.11	.86
11. To be honest, you cannot really change how gifted you are.	3.64 (1.47)	.94	–.03	.87
12. You can learn new things, but you cannot really change your basic giftedness.	3.42 (1.43)	.94	–.05	.86
Physics-specific	3.56 (1.27)			
13. You have a certain amount of giftedness in physics, and you really cannot do much to change it.	3.70 (1.31)	.86	.07	.78
14. Your giftedness in physics is something about you that you cannot change very much.	3.49 (1.30)	.87	.08	.81
15. To be honest, you cannot really change how gifted you are in physics.	3.63 (1.38)	.90	.09	.88
16. You can learn new things in physics, but you cannot really change your basic giftedness in physics.	3.44 (1.35)	.88	.09	.84
Percent of variance		55.14	24.15	

* On a Likert scale ranging from 1–6; higher values indicate malleable beliefs.

We conducted a correlation analysis based on Spearman's *rho* to find out how the mindsets about intelligence and giftedness were related to each other, to gender, and to the grade level (Table 3). We followed a non-parametric procedure given that none of the variables were normally distributed, and we included the only two fourth-grade students in the third-grader group. In the overall data, students' mindsets about intelligence were moderately related to their views on giftedness (*rho* = .379, $p < .01$). As Table 4 shows, these correlations were highest among the second-graders (*rho* = .552, $p < .01$) and females (*rho* = .491, $p < .01$). Paired samples *t*-tests revealed a statistically significant difference between the two mindsets for both genders and on every grade level (Table 4).

Table 3: Spearman's rho correlations in the student sample.

Variable	Mindset about intelligence	Mindset about giftedness	Gender
Mindset about giftedness	.379**	—	
Gender	–.047	–.166*	—
Grade level	–.087	–.212**	.117

* $p < .05$, ** $p < .01$.

Table 4: Views on intelligence and giftedness in different student categories.

Student characteristic	*N*	Mindset about intelligence		Mindset about giftedness		Spearman's *rho*	Paired samples *t*-test
		M	*SD*	*M*	*SD*		
Gender:							
Female	102	4.29	0.89	3.70	1.15	.491**	*t*(101) = 5.764***
Male	59	4.16	1.07	3.22	1.43	.204	*t*(58) = 4.448***
Grade level:							
First	62	4.35	0.98	3.75	1.23	.379**	*t*(61) = 3.571**
Second	52	4.24	0.86	3.76	1.21	.552**	*t*(51) = 3.415**
Third	50	4.13	1.01	3.06	1.27	.248	*t*(49) = 5.335***
Entire sample	164	4.25	0.95	3.54	1.27	.379**	*t*(163) = 7.049***

** $p < .01$, *** $p < .001$; scale of 1–6, higher values indicate malleable beliefs.

The grade level correlated negatively but weakly with the students' views on giftedness (*rho* = –.212, $p < .01$). The result of Levene's test ($p = .784$) was not significant, therefore we conducted a one-way analysis of variance (ANOVA). The result showed a statistically significant difference between the grade levels ($F(2) = 5.486$, $p = .005$, $\eta_p^2 = .06$). Further, Bonferroni post hoc tests revealed that the third-graders' views on giftedness were statistically significantly more fixed than those of the first-graders and the second-graders ($p = .011$, $p = .015$, resp.).

There was a weak correlation between gender and views on giftedness (*rho* = –.166, $p < .05$), female students ($M = 3.70$, $SD = 1.15$) having a more malleable mindset than their male counterparts ($M = 3.22$, $SD = 1.43$). Given that the variable was not normally distributed in either gender, and that Levene's test ($p = .012$) was significant, we compared the genders by conducting a nonparametric Mann-Whitney U -test. The result showed a statistically significant difference ($U = 2410.5$, $p = .036$, $d = .370$) with a mean rank of 86.87 for females and 70.86 for males.

The mean grade-point-average score for the students' physics courses was 8.70 ($SD = .84$) among the females and 8.94 ($SD = .72$) among the males: the difference was not statistically significant.

Teachers

The Kaiser-Meyer-Olkin measure, *KMO* = .884, indicated a meritorious level of sampling adequacy, and Bartlett's test of sphericity was significant ($p = .000$). PCA identified two principal components with eigenvalues exceeding Kaiser's criterion of 1, explaining 82.74 percent of the variance. The first component consisted of general and physics-specific items related to intelligence, and the second of overall and physics-specific items related to giftedness (Table 5). An acceptable level of internal consistency was achieved, the alpha coefficient being 0.967 for the eight intelligence items and 0.969 for the eight giftedness items.

Table 5: Items, means, component loadings, communalities (h^2), Cronbach's Alphas, and percentages of variance in the teacher sample (N = 131).

Item	*M* (SD)*	Comp. 1	Comp. 2	h^2
Mindset about intelligence	4.48 (1.09) α = .967			
General	4.32 (1.13)			
1. You have a certain amount of intelligence, and you really cannot do much to change it.	4.43 (1.21)	.92	.00	.84
2. Your intelligence is something about you that you cannot change very much.	4.22 (1.19)	.92	–.08	.79
3. To be honest, you cannot really change how intelligent you are.	4.44 (1.16)	.94	–.07	.83
4. You can learn new things, but you cannot really change your basic intelligence.	4.19 (1.31)	.87	.01	.76
5. Physics-specific	4.63 (1.15)			
6. You have a certain amount of intelligence in physics, and you really cannot do much to change it.	4.70 (1.18)	.90	.07	.87
7. Your intelligence in physics is something about you that you cannot change very much.	4.61 (1.17)	.89	.06	.84
8. To be honest, you cannot really change how intelligent you are in physics.	4.69 (1.18)	.90	.05	.86
9. You can learn new things in physics, but you cannot really change your basic intelligence in physics.	4.52 (1.28)	.86	.06	.79
Mindset about giftedness	4.10 (1.21) α = .969			
General	3.99 (1.23)			
10. You have a certain amount of giftedness, and you really cannot do much to change it.	4.22 (1.30)	.20	.75	.75
11. Your giftedness is something about you that you cannot change very much.	3.87 (1.29)	–.08	.95	.82
12. To be honest, you cannot really change how gifted you are.	4.03 (1.34)	–.02	.93	.85
13. You can learn new things, but you cannot really change your basic giftedness.	3.82 (1.36)	–.10	.94	.81
14. Physics-specific	4.20 (1.28)			
15. You have a certain amount of giftedness in physics, and you really cannot do much to change it.	4.33 (1.31)	.18	.81	.84
16. Your giftedness in physics is something about you that you cannot change very much.	4.19 (1.31)	.03	.90	.83
17. To be honest, you cannot really change how gifted you are in physics.	4.25 (1.34)	.03	.93	.89
18. You can learn new things in physics, but you cannot really change your basic giftedness in physics.	4.05 (1.39)	–.03	.95	.87
Percent of variance		63.28	19.46	

* On a Likert scale ranging from 1–6, higher values indicate malleable beliefs.

A paired samples *t*-test revealed a statistically significant difference between the overall and the physics-specific items related to intelligence ($t(130) = 5.486$, $p = .000$, $d = 0.479$). Likewise, there was a statistically significant difference between the overall and the physics-specific items related to giftedness ($t(130) = 3.699$, $p = .000$, $d = 0.323$). However, given that the effect sizes were small and the mean values were located close to each other, all indicating moderately neutral views, we did not find it useful to separate the items into general and physics-specific subcategories for further analysis.

The correlations between implicit beliefs and the background variables were subjected to the Spearman's *rho* test (Table 6). Over the entire sample, the teachers' views on intelligence correlated moderately with their views on giftedness (*rho* = .531, $p < .01$). Paired-samples *t*-tests revealed differences in teacher characteristics, however (Table 7). First, teachers whose major subject was physics understood that the nature of intelligence and giftedness are inherently different, whereas the teachers with mathematics as their major did not. Second, teachers with 21, or more, years of experience teaching physics did not differentiate between their intelligence and giftedness mindsets, whereas those with 20, or less, years of experience did make the distinction. Third, teachers with the most experience at the lower-secondary level had different beliefs about intelligence compared to giftedness, whereas those with the most experience in upper-secondary school made no such distinction.

Table 6: Spearman's rho correlations in the teacher sample.

Variable	Mindset about intelligence	Mindset about giftedness	Gender	Major subject	Teaching experience
Mindset about giftedness	.531**	—			
Gender	–.012	–.086	—		
Major subject	–.060	–.050	.031	—	
Teaching experience	–.275**	–.072	.055	–.309**	—
Level on which the most experience	.021	.244*	.139	–.328**	.294**

* $p < .05$, ** $p < .01$.

Table 7: Views on intelligence and giftedness in different teacher categories.

Teacher characteristic	*N*	Mindset about intelligence		Mindset about giftedness		Spearman's *rho*	Paired samples *t*-test
		M	*SD*	*M*	*SD*		
Gender:							
Female	58	4.51	1.06	4.23	1.14	.569**	$t(57) = 2.221$*
Male	68	4.44	1.14	3.94	1.27	.497**	$t(67) = 3.439$**
Major subject:							
Physics	71	4.55	1.05	4.15	1.21	.520**	$t(70) = 3.033$**
Mathematics	43	4.41	1.07	4.05	1.16	.398**	$t(42) = 1.984$
Experience (years):							
≤ 5	36	4.89	0.68	4.27	1.24	.391*	$t(35) = 3.258$**
6–10	26	4.67	1.07	4.08	1.17	.311	$t(25) = 2.296$*
11–20	37	4.30	1.27	3.98	1.23	.659**	$t(36) = 2.152$*
≥ 21	32	4.05	1.11	4.05	1.23	.621**	$t(31) = –.015$
Level on which the most experience:							
Lower secondary	43	4.42	1.11	3.91	1.11	.420**	$t(42) = 2.847$**
Upper secondary	53	4.43	1.14	4.36	1.10	.672**	$t(52) = .641$
Entire sample	131	4.48	1.09	4.10	1.21	.531**	$t(130) = 3.929$***

* $p < .05$, ** $p < .01$, and *** $p < .001$; scale of 1–6, higher values indicate malleable beliefs.

Teaching experience correlated negatively but weakly with the teachers' mindsets about intelligence (*rho* = –.275, $p < .01$). Given that the views were not normally distributed in either of the experience categories (Table 7), and that Levene's test ($p = .012$) showed significance, we carried out a nonparametric Kruskal-Wallis one-way analysis of variance to examine the differences. There was a statistically significant difference between the experience categories ($H(3) = 10.107$, $p = .018$). More specifically, pairwise comparisons placed a statistically significant difference ($Z = 3.048$, $p = .014$, $r = .39$) between the least experienced (≤ 5 yr.) (mean rank = 41.67) and the most experienced (≥ 21 yr.) (mean rank = 26.44) teachers.

Further, the school level on which the teachers had the most experience correlated weakly with their beliefs about giftedness (*rho* = .244, $p < .05$). Those with most experience on the upper-secondary level had more malleable ideas than those with most experience on the lower-secondary level. However, the *t*-test indicated that the difference was not statistically significant.

Students and teachers compared

The teachers were more malleable than the students in their mindsets about intelligence, and a similar result held for giftedness. However, the results of the *t*-tests showed that students and teachers differed statistically significantly only regarding giftedness ($M_{teachers} = 4.10$ (1.21), $M_{students} =$ 3.54 (1.27), $t(293) = 3.802$, $p = .000$, $d = .446$).

Discussion

We investigated the mindsets of academically gifted Finnish students at upper-secondary school (N = 164) and Finnish physics teachers (N = 131) about overall and physics-specific intelligence and giftedness. The results showed that both students and teachers had somewhat malleable mindsets about intelligence, which regarding the students is in line with the findings from a study of students on a summer program conducted by Feldhusen and Dai (1997). Moreover, because of the high physics grades achieved by the students in our study, the results follow a similar trend as observed by Kuusisto et al. (2017) indicating that students' fixed views on giftedness related to higher grades in mathematics. However, our results contrast with those reported by Leslie et al. (2015) and Scherr et al. (2017), although their research focused on the university level. The general trend indicating that teachers have more malleable mindsets than students is reasonable in the light of teacher ethics, according to which teachers should believe in their students' learning capabilities and continuous talent development (Tirri, 2016).

The most malleable mindsets about intelligence were observed among the newcomers, in other words first-year students and the least experienced teachers. The difference in malleability between grade levels was not significant among the students, but among the teachers the more experienced they were the weaker their malleability. On the other hand, mindsets about giftedness followed the opposite trend: there were differences related to grade level in the student sample, the third-graders being the most fixed, whereas mindsets about giftedness were not related to the length of teaching experience. We interpret these findings as reflecting a somewhat natural development in students during their school years. Although they compare themselves with their peers from early on, the last year of upper-secondary school is the most crucial for their future. By the time of the matriculation examination, most students' self-rated belief in their own abilities has stabilized on a certain level. However, views on giftedness appear to settle earlier than intelligence-related views, which were still observed to change among the teachers.

By placing themselves in the gray area between a clear fixed and a clear growth mindset, the students exhibited mixed views about the developmental idea of giftedness (Gagné, 2010; Subotnik et al., 2011). However, as Dweck (2000) states, using the term "gifted" in labeling students could in itself lead to fixed beliefs in that as "it implies that some entity, a large amount of intelligence, has been magically bestowed upon students" (p. 122). Although Finnish schools do not label students as gifted, it is possible that even using the term may interfere with their beliefs about giftedness. Consequently, our finding that the mindsets about intelligence were more malleable than those about giftedness verify the recommendation of Makel et al. (2015) to make a clear distinction between the two terms.

Among the students, gender was not related to their mindset about intelligence, but there was an association with giftedness. On average, the females' mindsets about giftedness were slightly malleable whereas those of the males were somewhat fixed. It should also be noted that physics grades did not differ between the genders. The observed gender-specific variance in mindsets is in line with the findings reported by Kuusisto et al. (2017) in a similarly Finnish context.

Although gender was not related to the teachers' mindsets about intelligence or giftedness, statistical analyses revealed interesting relations between differences in mindsets and specific teacher characteristics. Teachers with 21 years or more experience, with mathematics as their major subject or those acquiring most of their experience at the upper-secondary level did not think differently about intelligence and giftedness, whereas those with less experience, physics as their major or whose experience was mostly on the lower-secondary level made a distinction. These findings raise the question of whether school levels or changes in teacher education differ in ways that could explain the observed differences.

The overall and the physics-specific mindsets did not differ within the student sample. Instead, it was encouraging to find that the physics-specific views of the teachers were more malleable than their overall views. Although the difference was minor, it is indicative of teachers' attitudes to learning in their field. According to Dweck (2006), teachers' actions reflect their own mindsets. Physics is generally considered a difficult subject, thus their mindset may play a crucial role in their pedagogical choices, and in how they convey their own perceptions to their students.

The student data for this study was collected in a single school, hence it is questionable whether one could generalize the results to all gifted upper-secondary students in Finland. There are only a few Finnish schools in which all the students are high achievers, as in this school. It is more typical for the gifted to study among normal students in normal schools. Therefore, more research is needed to assess the possible impact of the school environment and their peers on the mindsets of gifted students in these schools. Furthermore, the teacher data was collected by means of convenience sampling and thus might not be sufficiently representative. However, it would have been practically impossible to adopt a sampling method that was not based on voluntary participation.

Conclusion

Mindsets offer an explanation for differences in gifted students' achievement goals and challenge-related behaviors. If we are to help these students in reaching their full potential in STEM subjects, we need to bring mindsets to the center of our attention. This study indicates that there is still room for mindsets about giftedness to move in a more malleable direction, especially among males and the oldest students.

Interventions, typically conducted by researchers, have proven beneficial in promoting growth mindset in students (Rissanen, Kuusisto, Tuominen, & Tirri, 2019). However, driving such changes with everyday teacher-driven pedagogical practices has been neglected both in classrooms and research. We suggest the framework for growth mindset pedagogy (Rissanen et al., 2019) to be applied in physics instruction by fostering formative assessment, in other words valuing learning over grades, and by embracing mistakes as a source for learning. Moreover, gifted students should not be protected from difficult tasks. This could be especially important for students with fixed mindsets, as they tend to respond to challenges in negative ways.

Given that a fixed mindset can develop at an early age (Dweck, 2000), it would be useful to study mindsets more thoroughly on lower school levels. If high-achieving young students undervalue persistence, they may face serious setbacks as subject matter becomes more difficult on upper-secondary level. Pedagogical tools such as student self-evaluation could also be used for providing teachers with practical feedback on students' implicit beliefs.

The teachers in this study held incremental views on intelligence and giftedness. However, it is not self-evident that all teachers with a growth mindset actualize it in their classroom practices. Teachers need tools to convey the idea of malleable human qualities to their students. Therefore, providing knowledge of mindsets and their implications should be an essential part of teacher education.

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