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Missing link between talent development and eminence: why gifted students abandon their pursuit of science

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ABSTRACT
Talent development in science is a national investment as it is key to enhancing national competitiveness. However, even after undergoing a 3-year training in a science gifted academy, 8.5% of South Korea's gifted students choose to enter medical school rather than pursuing a science or technology major. By conducting in-depth interviews with five participants, this study determines why talented students who are trained to become scientists at high schools and universities change their major to medicine. The participants were high school graduates gifted in science selected by purposive sampling according to the following criteria: Individuals entered medical school immediately after graduation, majored in a STEM at university and then entered a graduate school of medicine, and have a master's or doctoral degree in a STEM major but changed their major to becoming a doctor. This study investigates students who have lost motivation for a pure STEM career to reflect on the educational and social driving forces that would have enabled them to continue on their path to become scientists. In addition, as it examines the current controversy over these individuals' career choices, the study has implications for the development of talent development goals from a macro perspective.

KEYWORDS
Talent development; STEM; career change; gifted education; motivation trajectory

Introduction

The South Korean education system includes two types of science-gifted high schools for students who are talented in mathematics and science: the Science High School and Science Academy . These gifted schools provide good facilities, excellent teachers, and ample opportunities for their students to learn science from mentoring scientists. They select students from across the country who demonstrate exceptional ability and potential for extraordinary achievements in math and science. Their goal is to develop talent and enable the achievement of outstanding levels of creative, academic contributions.

Each talent has a different trajectory, including when a talent first appears, when production or achievement generally peaks, and when participation in a realm generally ends (Olszewski-Kubilius et al., 2019; Olszewski-Kubilius et al., 2016). Scientific talent is a domain-specific talent, associated with logical/mathematical intelligence, which is usually discovered at a relatively early age (Subotnik et al., 2011, 2012). Building competencies once they have been discovered requires phases of acceleration and reinforcement (Subotnik et al., 2011). This development stage involves continuously training the basic contents and thinking methods of science, technology, engineering, and math (STEM) (Almarode et al., 2014). The High School for Gifted and Talented Schools is designed to provide intensive training and advanced enrichment in science for gifted students.

For this high-quality and intensive science education, the nation invests significant financial and resources. The nation provides good facilities, excellent teachers, and opportunities to explore science through mentoring by scientists. This investment is made because of the expectation that the science gifted will contribute to the development of the nation and society through the development of their talents. The choice to do so is based on the belief that scientific and technological development is directly related to national competitiveness (Audretsch et al., 2002; Stephan, 1996). During a sense of crisis (e.g., because there are fewer young people who must support a large number of older people due to low fertility)

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improving national competitiveness through nurturing talented people in science and engineering is considered a national investment (Korea Ministry of Education, 2018; Korea Ministry of Science and ICT, 2018).

Students who received support for scientific talent development by attending a gifted school or science high school are encouraged to enter the fields of pure science, applied science, and engineering. Educational policy opposes career paths in medicine because the purpose of these schools is to foster human resources in the science and engineering (S&E) fields. When they entered the school, students recognized that they received special education at in this school to develop their scientific talents. In addition, applicants were informed that there would be disadvantages (e.g., requesting a full refund of tuition) when entering the medical field that goes against the purpose of the school, and they agreed (Korea Ministry of Education, 2020). Others, on the other hand, are questioning this regulation because it limits students' autonomous choices. Because even if students agree to choose a S&E major at the time of admission to gifted school, they may change while in gifted school. There are also those who argue that it is rather a national loss to block their opportunity to achieve eminence in the medical science (Jang, 2021).

Despite these regulations, however, in the past 3 years, 12.9% of the graduates from eight gifted schools nationwide applied to the medical field, and 8.5% of them went on to medical college. Among them, the gifted school with the highest rate of admission has seen 23.7% of its students enroll in the medical major in the past 3 years (World Without Worry about Private Education, 2021). Given this tendency toward, medicine, it is necessary to investigate the underlying reasons why students abandon their pursuit of S&E and to apply for medical school in terms of their talent development and motivation.

Literature review

In order to examine the reasons for the career change of science gifted students, it is necessary to find out what factors influence students' major/vocational choices, especially in the STEM field. Su et al. (2009) investigated the magnitude and variability of gender differences in vocational interests. They found a things-people dimension of interest could play an important role in gender occupational choices and gender disparities in STEM fields. In a study by Ceci and Williams (2010), which identified the causes of underrepresentation of women in fields requiring intensive use of mathematics, they argued that career paths included both cognitive abilities to pursue careers and motivation to use those abilities. They concluded that preference and choice are the most important causes of underrepresentation in women. Wang et al. (2017) investigated whether relative cognitive strengths and interests in math, science, and language domains in high school were more predictive of STEM occupational employment than absolute cognitive abilities alone. They found that in the high-verbal/high-math/high-science ability group, which is similar to gifted students in science, individuals with higher science task values and lower orientation toward altruism have a stronger tendency to choose STEM occupations.

Lubinski and Benbow (2006) used the lens of The Theory of Work Adjustment (TWA) to determine gender differences in educational settings and the world of work in several cohort groups of the Study of Mathematically Precocious Youth (SMPY). TWA assumes that the individual and the environment interactively influence the choice and retention within a career. An individual's learning or work personality is analyzed as two major components of abilities and preferences (interests and values), whereas the environment is divided into the corresponding domains of ability requirements (meet performance expectations) and reinforcement systems (performance recognition and rewards). When individual interests and vocational rewards match, and when individual abilities match the abilities required by the job, individuals can continuously develop their talents. In summary, individual factors that affect students' majors or careers in STEM areas are interests, values, abilities, and altruism. Influential environmental factors are ability requirements and reinforcement systems.

Research question

The research questions are as follows.

(1) Is there continuity of talent development in S&E when students choose to pursue medical school?
(2) Why do students abandon their pursuit of a S&E career?

This study aims to examine the motivation for continuing talent development and how it can be supported. In addition, as it examines a current controversy over the career choices made by gifted students, this study has implications for identifying the factors that enable the transition of potential to excellence in science talent development.

Method

Research design overview

This study aims to understand why students changed their career paths through in-depth interviews with five people who graduated from science gifted schools and entered medical school, or who went on to major in S&E and then transferred to medical school using the interpretive paradigm for analysis. The framework for the study is that science gifted students' career choices are a function of the interaction of their personal attributes with their life process and social situation (Lichtman, 2010).

Study participants

Researcher description

The researcher is studying science gifted education, especially effective talent development for science gifted students at the high school level. Research participants were recruited according to the criteria below and there is no personal acquaintance between them and the researcher.

Participants

The participants of the study are as follows: Anna and Edan each chose a STEM major after graduating from a science-gifted high school. Anna obtained a master's degree, whereas Edan obtained a bachelor's degree and then enrolled in medical school; currently, Edan is a doctor. Brandon majored in mathematics at the undergraduate school after graduating from a science-gifted high school. He took the college entrance examination again and started attending medical school; currently, he is in the first year of pre-medical course (In Korea, medical schools have 2–4 system for bachelor that is 2 years of pre-medical course, including humanistic, social science and medicine-related subjects, and 4 years of medical course) Charles and Daniel entered medical school immediately after graduating from a science-gifted high school; they are currently in their third year of standard course in medical school.

Participant recruitment

Recruitment process

For this study, teachers who had worked at a gifted school for more than 10 years were asked to identify students who had a profile that met the conditions of the study. The purpose of the study, process, compensation, and method of data disposal after the study were explained to the six candidates who were contacted by e-mail and consent was obtained. Among them, five agreed to participate in the study, and all five were selected as research participants.

Participant selection

Study participants were recruited using critical case sampling to permit logical generalization and maximum application of information (Suri, 2011). Five graduates from a science-gifted high school were selected using purposive sampling according to the following criteria (Table 1): Those who graduated from a science high school or science academy and entered a medical school immediately after graduation or who majored in a STEM field at university and then entered a graduate school of medicine. Study participants also included individuals who were initially pursuing a degree in a STEM major but changed their major to become a doctor. In South Korea, medical education requires students to attend a 6-year bachelor's course after high school graduation. The Graduate School of Medicine is a 4-year master's program that admits individuals with diverse bachelor's degrees and trains them to become doctors.

Table 1. Participant characteristics.

Name*	Age (years)	Gender	Occupation	Major before change
Anna	34	Female	Fellow	After graduating from science high school, she majored in bio science at the undergraduate level and obtained a master's degree in the same major; subsequently, she entered medical school.
Brandon	22	Male	Medical school student (Pre-Med, 1st year)	After majoring in mathematical science in undergraduate school, he entered medical school after attending the university entrance examination.
Charles	24	Male	Medical school student (Standard, 3rd year)	After graduating the gifted high school, he entered medical school
Daniel	24	Male	Medical school student (Standard, 3rd year)	After graduating the gifted high school, he entered medical school.
Edan	34	Male	General practitioner	After graduating the science high school, he majored in engineering at the undergraduate school and entered medical school.

*All names are pseudonyms.

Data collection

Data collection/identification procedures

This study adopted a case study approach because it provides a rich description of an individual's experience and helps clarify their experiences multidimensionally (Creswell, 2007). Further, the study used semi-structured interviews to collect relevant data. The semi-structured interview questions covered the following topics: (1) reason for deciding to receive science-gifted education, (2) reason for abandoning the pursuit of science, and (3) the effect of science talent development education on one's current life. Questions were added according to each participant's responses, as well (Lichtman, 2010).

Recording and data transformation

Interviews were conducted three times per person, and face-to-face interviews were not possible due to COVID-19, so voice interviews were conducted over the phone. Each interview took between 40 and 60 minutes. The five participants were interviewed over a 4-week period. All the interviews were transcribed and sent to the participants for confirmation as soon as each transcription was completed. The analysis of each interview began immediately after transcription.

Analysis

Data-analytic strategies

By reading the transcripts of each case repeatedly, we tried to capture an overall understanding of the participants' experiences and perceptions. By perusing the transcripts several times, finding and displaying meaningful phrases or sentences, repeated themes were found and concepts were extracted. Through a repeated process of reviewing the extracted concepts and examining the transcripts, the concepts related to core topics of the research problem were identified (Creswell, 2007; Saldaña, 2016). In addition, we tried to further secure the validity of the research results whether the topic extracted through the transcripts is appropriate by verifying the objective analysis of the core topics with confirmation by three qualitative research experts.

Methodological integrity

As the participants knew the social antipathy for their choice, it was likely that it would be difficult to talk honestly about the reasons they changed their major. Therefore, an effort was made to understand the true story of the research participants. The researcher explained the purpose of the study to the study participants and informed them that anonymity was guaranteed. Prior consent was obtained for the recording. In addition, it was fully explained how the researchers would utilize and manage the transcribed recordings. Two researchers independently performed the coding for science-gifted education. Subsequently, we discussed the analysis results until inter-rater reliability is higher than 90%, and we finally reached an agreement.

Results

Continuity/discontinuity of talent development education and their current life

Among the study participants, three students who changed their careers after majoring in S&E responded that their learning at gifted schools was not related to their current careers. Meanwhile, the two students who chose medicine right after graduating from the gifted school responded that the development of scientific talent was the basis for medical learning, or that they expected that the material could converge.

Discontinuity of talent development education and current life

Participants were questioned about whether receiving science-gifted education at science high schools affected their current lives. Interestingly, all three of the research participants who had changed their majors to medicine after choosing S&E majors at university answered that they experienced only an insignificant effect. They felt that the science-gifted education they had received was disconnected from their current lives as doctors or medical students. Some of their responses are as follows:

> "It didn't affect my life very much." (Anna)

> "It influenced my first major selection (mathematical science) but not the second (medicine)." (Brandon)

> "It didn't help much except that I made a lot of smart friends." (Edan)

Continuity of talent development education and their current life

Daniel felt that science-gifted education provided him with a basis to understand medicine. In other words, science-gifted education was indirectly helpful to participants in their present lives.

> The biggest advantage that students gifted in science obtain from accessing all disciplines, including medicine, is that they develop a logical and systematic learning approach. In particular, I studied physics in detail in science high school; I could apply the same approach later to study cardiac physiology, respiratory physiology, and the functional anatomy of the nervous system in medical school. (Daniel)

Charles felt that, unlike other research participants, he did not "change" his major to medicine, but first chose medicine to further his knowledge in the biomedical engineering field, which fuses medicine and engineering. According to him, science-gifted education helped him understand the fusion of medicine and engineering.

> I wanted to study medical engineering, especially surgical robots, and I entered medical school because I felt that medical knowledge was essential for this. Through gifted education, I was able to access various fields of study, and through academic and research activities, I achieved clarity on what I really wanted to do. (Charles)

Reasons they abandoned their pursuit of a S&E career

Reasons the students abandoned their pursuit of S&E careers falls into two categories: personal reasons and environmental reasons. Personal reasons included 1) Low interest in science but high interest in educational resources of science-gifted high schools, 2) Interest in a different direction and altruism, and 3) Possession of insufficient ability to become a scientist. The environmental reason was a perception of unsatisfactory reinforcement because of poor professional prospects of S&E fields.

Low interest in science but high interest in educational resources of science-gifted high schools

Compared to general high schools, science-gifted high schools provide higher-quality education, including excellent instructors, cutting-edge facilities, and an autonomous curriculum. Anna said that she decided to receive science-gifted education to enjoy the better educational resources provided by science high schools.

> Because I was good at studies, the gifted school allowed me to learn at a higher level in a better environment. I didn't particularly want to become a scientist. But there were few places other than science high schools from where gifted education in science could be obtained. (Anna)

For gifted children, interactions with similarly gifted peers is important for both cognitive development and emotional fulfillment. For instance, after having a difficult time adjusting to the peer culture of a general middle school, Edan decided to attend the science high school.

> I can focus on studying what I want without disturbing the other kids trying to study. In middle school, there was a peer culture that hindered students from studying hard. That was so difficult. I wanted to go to a high school that only enrolled students like me. (Edan)

In some cases, students decided to attend a science-gifted high school to follow gifted friends who influenced or communicated well with them.

> When I was in middle school, there was an alumnus who promoted my curiosity about math every time. This friend enrolled in a science-gifted high school early, and I followed him there by applying the following year. (Daniel)

Interest in a different direction and altruism

Daniel wanted to choose a job that would enable him to help others; further, he recognized that a doctor could help others more directly than a scientist.

> In my second year of high school, after my mother suffered a cancer recurrence, I felt that I wanted to save people and thought that what I had studied would directly help people. Science, of course, helps people, but medicine can directly save someone's life. (Daniel)

Possession of insufficient ability to become a scientist

Anna majored in science and received her master's degree but said that she realized her lack of talent for science before pursuing her doctoral degree and, accordingly, changed her major to medicine. By lack of talent, she meant that she did not have sufficient skills to realize excellent results in science. Further, she recognized the pressure she was under to generate new knowledge and cited it as one of the reasons why she abandoned her pursuit of science.

> I'm lacking talent in science, and it doesn't suit me. Staying up all night doesn't mean I'll get great results. It is difficult to keep creating new things. But by studying medicine, I can use my knowledge to save lives. Also, the more I know, the more people I save. (Anna)

Unsatisfactory reinforcer because of poor professional prospects of S&E fields

Two participants who first chose S&E majors and then changed to medicine did so on becoming aware of the poor occupational prospects of S&E fields including by several factors: uncertainty about future employment, low wage rates compared to doctors, strong labor intensity, and the need to study abroad. They said that their negative perceptions of S&E majors contributed to their decision to change their majors to medicine.

> I liked math the most, so I thought it would be best to choose a related job. In addition, my antipathy toward the medical school influenced my choice of major. But I came to think it wrong to simply study what I like as my major; so, I changed my major again. I was frustrated with the insufficient support provided by schools to study science and engineering, relatively low competitiveness of domestic graduate schools, and nature of Korean society that considers it acceptable for students to study abroad. (Brandon)

> In graduate school, it takes at least 5 years to finish my doctoral course and I don't know when it will be finished. In the meantime, I have to work hard every day, although my salary is at the lowest hourly level. There is no guarantee that I will find a job after completing the course. There are many seniors who continue to work in the lab while doing their postdocs. Still, the salary is that level. But if I become a doctor, my salary increases by at least five times. Employment is easy and there is no retirement age. I thought it would be better to be a doctor if I was going to struggle all night. (Edan)

Discussion

By examining the current controversy in Korea over the career of students who have attended elite, specialized STEM schools in Korea, this study reveals some findings that have macro-level implications for the establishment of a range of talent development goals and pathways for students. Similar to the talent development process, the motivation to pursue development of students' talent has trajectories, with ups and downs and transitions. What is the motivation for continuing talent development in STEM and how should it be supported and cultivated?

Continuation of talent development should be considered from two perspectives according to TWA model (Lubinski & Benbow, 2000): the individual and the environment. From the individual point of view, the reasons for giving up on pursuing an S&E career can be improved through schooling about science task value. Students who choose medicine rather than S&E careers, although they have the opportunity to study science in depth by entering a school for the gifted, may see it as merely an opportunity to broaden their personal network or receive high-quality educational services. They did not appreciate the intellectual, personal, and social value of science study which are some of the most important factors for abandoning their pursuit of science.

For students who choose medicine rather than S&E majors "to help people," rebranding the field of S&E to jobs that benefit society and provide opportunities to interact with people could foster scientific interest and reduce misconceptions (Diekman et al., 2011). Marketing S&E careers as people-oriented and helpful can encourage the recruitment of a wider variety of talented young people. (Ceci & Williams, 2010).

There is a need to improve the selection system for gifted schools focusing on a better match between the individual abilities and characteristics required in science field and that are used by gifted schools for selection. According to the nature of science and the goal of the STEM schools there should be a greater focus on identifying students with the potential to become creative producers (Subotnik et al., 2011, 2021) not just high performers in memorizing science knowledge. However, gifted schools sometimes choose high performers over creative producers. Hence, rather than becoming scientists (producers), who generate new knowledge, some students make use of their ability by becoming doctors (performers), who apply and utilize their knowledge.

From an environmental point of view, increasing the direct benefits of STEM careers (e.g., salary, prestige) and raising the students' understanding of the versatility and variability within STEMfields and career can be a strategy to prevent leakage of the talent development pipeline. There is a big difference in job stability and wages between S&E jobs and medical jobs. Over the years, depending on the contribution of scientific and technological capabilities to national competitiveness, the government has actively supported pursuit of academic doctorates. However, there has been no corresponding increase in academic jobs, and the labor market conditions for new scientists are worsening every day (Science and Technology Policy Institute, 2020). Because Korea's labor market is very competitive, this may cause students who have chosen S&E professions to give up their careers and choose medicine.

When a multipotential student chooses a S&E related (e.g., medicine) or non-S&E major (e.g., jurisprudence) for interdisciplinary convergence, seeking to work across multiple fields, this should be perceived as a worthy outcome of a specialized STEM education (Greene, 2003). This is because such students can create new fields of work, achieve eminence and make important societal contributions by facilitating the fusion of STEM and non-STEM domains.

Conclusions

For the transition of scientific talent to outstanding achievement in STEM fields, individual abilities, interests, and psychosocial skills should be fostered at the individual level, but the support and encouragement of the scientific community should also be obtained, including the government, society and educational institutions. Educational institutions should select and educate gifted students according to their purpose, and the scientific community should provide social honor and economic rewards to such students so that they can display their talents throughout their lives. In addition, plans should be prepared to help them in their efforts to merge their talent area with other non-STEM areas of interest or develop new areas. Similar to other case studies, this study is limited in that it lacks generalization potential. In other words, although this study provides a vivid description of scientific talent development and its impact on participants' lives, this result cannot be generalized to different populations.

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