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Catalysts and Deterrents for STEAM Talent Development of Students from Economically-Disadvantaged Families Through Specialized STEAM Talent Residential High Schools

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Abstract
Talent developmental experiences of economically disadvantaged students of Specialized STEM Talent Residential High Schools (SSTRHS) were investigated. Nine students who were preferentially admitted to SSTRHS due to their families' economic disadvantage were interviewed twice on their experiences from early childhood to college. The data were verified by checking with survey data, national gifted education data and interviews with master teachers. A thematic analysis revealed that STEM talent was recognized early by parents and acknowledged through competitions. However, there were limited resources and opportunities for them to study advanced mathematics systematically and intensely until they entered SSTRHS. At the SSTRHS, they struggled with an extremely accelerated math curriculum. However, with support from advanced peers and teachers,

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they could cope with their weaknesses caused by limited dosage of STEM learning. Experience conducting research with peers and mentors were the most critical catalysts for their planning for future careers as research scientists.

Keywords
economically disadvantaged, STEAM, talent development, Specialized STEM Talent Residential High Schools

Introduction

Based on perceived needs of a state, country, and family, societies may promote STEM talents (Thomas & Williams, 2010). Talent development of gifted individuals requires a provision of learning opportunities with which a student's talent can be recognized and developed (Subotnik et al., 2011). Specialized Science Talent Residential High Schools (SSRHSs) were established in many countries to provide opportunities for gifted individuals to develop their STEM talents. In South Korea, there are eight SSTRHS which recruit about top 837 students each year across the country (National Science Gifted Information, 2022) and use curriculum focusing on STEM or STEAM, that were intensely accelerated, inquiry-based, problem-based, and project-based (Park, K. & Seo, 2005; Park, S., 2005). Two of the eight SSTRHSs provide STEM and arts integrated curriculum (STEAM), whereas the other six SSTRHSs focused more on STEM curriculum (See Table 1).

However, economically disadvantaged gifted students (EDGS) are underrepresented in gifted education programs. In 2014, 11% of South Korea's student population belonged to low-income families (Park et al., 2017), but only 1.81% (2,146 students) of this group participated in gifted education program (Lee, S. & Lee, K.S., 2015). Research has illustrated the widening of the excellence-achievement gaps among students with a low socioeconomic status (SES) (Finn & Northern, 2018; Lamb et al., 2019; Plucker et al., 2013; Plucker & Peters, 2016). In addition, students with high potential from lower income families "lose more educational ground and excel less frequently than their higher income peers" (Plucker & Peters, 2016; Wyner et al., 2007, p. 4). Efforts to recognize, acknowledge, and address these achievement barriers to academic excellence are imperative (Borland & Wright, 1994; Olszewski-Kubilius & Clarenbach, 2012).

Private tutoring is one of the critical factors influencing excellence gap especially during the middle school period in South Korea (Choi & Paik, 2017; Lee, S. & Lim, H, 2016). 75.5 % of Korean students get after-school private tutoring spending monthly average of $305 (ranges from $96 to $466) per household in 2021 (Korean Statistical Information Service, 2021). Special private tutoring for acceleration or enrichment in preparation of entering specialized high schools is available for gifted students in upper elementary and middle schools and is offered by only a few cram schools at high cost (Park & Lee, 2009). However, a narrow circle of affluent and well-informed families can

Table 1. Curriculum Structure of Specialized Science (and Art) Talent Residential High Schools.

	Specialized Science Talent Residential High Schools						Specialized Science and Art Talent High Schools	
School	A	B	C	D	E	F	G	H
Humanities (%)	60(34.48)	63 (35.00)	62(35.43)	58(32.58)	62(34.25)	64(31.11)	55(31.61)	48(26.67)
Science (%)	76(43.68)	84(46.67)	81(46.29)	90(50.56)	87(48.07)	92(50.56)	83(47.70)	92(51.11)
Interdisci-plinary(%)	8(4.60)	7(3.89)	6(3.43)	6(3.37)	4(2.21)	6(3.33)	21(12.07)	18(10.00)
Research (%)	30(17.24)	26(14.44)	26(14.86)	24(13.48)	28(15.47)	27(15.00)	15(8.62)	22(12.22)
Credits (%)	174(100)	180(100)	175(100)	178(100)	181(100)	180(100)	174(100)	180(100)

access such special private tutoring. Due to its high cost and limited network, low-income children have limited access to the private tutoring for acceleration or enrichment resulting in excellence gap (Plucker & Peters, 2016).

This study is a part of the national longitudinal study on the development of Korean scientifically talented students who attended SSTRHS. With the policy of preferential admission of underrepresented gifted students, these schools can allocate up to 10% of their total enrollment to underrepresented groups of students. This study examines the experiences of EDGS before, during, and after their studying at SSTRHS in terms of talent recognition and development to find out catalysts and deterrents that determine their talent development of EDGS. It is anticipated that findings can be useful for exploring effective means and resources to reduce the excellence gap of ELDGs.

Review of Literature

The Mega model of talent development proposed by Subotnik, Kubilius-Olszewski, and Worrell (2011) defined giftedness as a performance that is clearly at the upper end of the distribution in a specific domain. They claimed three most relevant principles for understanding talent development mechanism based on an extensive review of studies with eminent people across the life-span. They are: (a) importance and domain-specificity of timing for 'start', 'peak', and 'end' of a developmental trajectory for talent; (b) the importance of the availability of opportunities for talent development throughout the talent development process; and (c) the importance of psychosocial variables (e.g., motivation, a willingness to take calculated risks, and an ability to cope with challenges). STEAM talents need to be recognized early. Especially math talent can be recognized at the earliest than other talent domains.

Several studies (Bloom, 1985; Briggs and Renzulli, 2009; Gottfried and Gottfried, 1996) also summarized catalysts for transformation in terms of their personal and environmental characteristics. Reported are important catalysts for talent development: personal characteristics such as passion, grit, interest, achievement, and creativity (Cho & Lin, 2011; Gagné, 2005; Subotnik et al., 2011); instruction and curriculum based opportunities and competitions (Borland and Wright, 1994; Campbell and Walberg, 2010; Yang et al., 2021); and important people in their lives, such as parents (Cho & Lin, 2011; Nokelainen et al., 2007); and motivated and gifted peers, and certain teacher characteristics (Cho & Campbell, 2011). Especially, at the middle stage of talent development, gifted students' learning gains result from complex, advanced, and meaningful content provided by a knowledgeable teacher through high-quality curricula and instruction at an appropriate pace with scaffolding techniques and feedback (Park, 2005; Subotnik et al., 2011; Tomlinson & Jarvis, 2014). These elements exert influence that increase with dosage and within structures that facilitate student engagement in rigorous experiences, including interactions with one another (Siegle et al., 2016). However, socioeconomic deprivation exerts powerful suppressive effects on talent development (Ambrose, 2005). In this study, the specific barriers and catalysts for talent development of students who studied at SSTRHS in South Korea were explored.

Research Methods

Thematic analysis was employed to analyze data collected through semi-structured interviews conducted twice during the high school and college periods

Participants

The purposeful sampling method was used to recruit and saturate participants. Inclusion criteria for this study were talented students who were preferentially admitted to SSTRHS, in 2017 based on their economic disadvantages. Out of 46 students who were preferentially admitted to all eight SSTRHS in South Korea, nine students belonged to the category of EDGS whose families' monthly income was lower than $2,650, which is 25% lower than a Korean family's median income, as of 2017.

Students in other underprivileged categories (e.g., students with disabilities, foster home children, etc.) were excluded from this study. First survey was conducted in 2017 when participants were in Grade 10 at SSTRSH. First and second interviews were conducted in 2019 in Grade 12 and in 2020 of their college freshmen year respectively. For confidentiality, they were renamed as S1 to S9. Survey data were used for verification of the trustworthiness of interview data in this study.

Table 2 presents profile information about participants. S1 to S6 attended science high schools, whereas S8 to S9 attended science and art high schools. Majors in college ranged from 4 undecided, 4 engineering, and one science. They reported on continuing their studies to Ph.D. except S4 and S7. S4 plans to work as a civil servant and S7 as a professional due to families' financial situations.

Contrary to low-income level, parents' education levels were not very low, considering 50% of Korean adults were college graduates in Year 2021. Most of them completed college and only one mother completed high school.

GPAs for mathematics and science for Grades 10, 11, and 12 were presented on a 5-point Likert scale with '1' for GPA below 1.24, '2' for grades between 2.5 and 2.9, '3' for 3.0-3.4, '4' for 3.5-3.9, and '5' for 4.0-4.5. Their math and science achievements were generally good or excellent and maintained or improved during 3 years at SSTRHS. Their 3-year average math GPA was 3.95, while their 3-year average science GPA was 4.32, with 4.5 as the maximum possible GPA. S4 had the lowest math GPA, 2', in the first year, but his math GPA improved in Years 2 and 3 to '3'.

The number of awards received from external organizations or institutions ranged from zero to 13. The number of awards were verified through the national Gifted Education Database system, which keeps records of all gifted students. If inconsistencies were noted, various documents or data sources were examined to verify them. S1 received the most awards as a gold medalist at the International Math Olympiad. They conducted two to ten research projects during high school period. Two to three projects are conducted as a part of the school curriculum and the rest as voluntary research projects with peers, teachers, or outside professionals during vacation or after-school hours. Satisfaction levels were marked on a 5-point Likert scale with '5' the highest. Participants' satisfaction with schools, teachers, and peers ranged from 3 to 5, meaning students were mostly positive.

Table 2. Demographic Profiles of Participants.

Student (Gender)	S1 (m)	S2 (m)	S3 (m)	S4 (m)	S5 (m)	S6 (m)	S7 (f)	S8 (m)	S9 (m)
High school attended	SHS	SHS	SHS	SHS	SHS	SHS	SAHS	SAHS	SAHS
College major	Undecided	Chemical bio eng	Undecided	Earth environ eng	Bioscience	Atomic eng	Material eng	Undecided	Undecided
Plan for graduate studies	Ph.D	Ph.D	Ph.D	Civil services	Ph.D	Ph.D	Professional	Ph.D	Ph.D
Education Father/ Mother	College/ Master	Master/ College	College/ College	College/ College	Master/ College	College/ College	Master/High school	College/ College	College/ Junior college
GPA math in grades 10/11/12	4/4/4	3/3/3	4/5/5	2/3/3	—	3/4/3	4/5/5	5/4/5	4/5/5
GPA science in grades 10/11/12	5/5/5	4/4/4	4/5/5	3/5/5	—	3/4/5	3/4/4	4/4/5	4/5/5
Awards (m = 3.57)	13	0	—	3	1	0	4	4	—
Research (m = 5.86)	6	7	—	10	7	3	6	2	—
Satisfaction with school (m = 4.11)	5.00	3.11	3.67	3.78	4.89	5.00	3.11	4.33	5.00
Satisfaction with Teachers(m = 4.35)	5.00	5.00	4.00	3.20	4.80	5.00	3.00	4.8	5.00
Satisfaction with peers (m = 4.08)	4.83	4.33	3.83	3.00	3.83	4.67	3.50	4.67	4.33

Interview Data Collection Protocol

Interviews with students were conducted twice in Grade 12 at SSTRHS and once as college freshmen through online. In-depth interviews were conducted to elicit rich information about personal experiences and perspectives (Russell et al., 2005; Strauss, 1987), guided by research questions which were semi-structured to allow for the discovery of ideas and themes (see Table 3). Questions were sent to 685 SSTRHS students in Grade 10 including nine participants of this study on their experiences of learning and development of their STEM talents from early childhood to college. To enhance trustworthiness of interview findings, the interview data were triangulated by comparing participants' responses to survey questionnaire and interviews with their high school master teachers. If there were any inconsistent responses, participants were briefly interviewed again to verify their responses. Steps to minimize bias included the systematic and consistent application of the interview protocol, non-presentation of interviewers' views, continuous seeking of clarifications of participants' responses, and maintenance of attitude of skepticism (Bryman, 2016). Member checking also took place through the presentation of detailed ten-minute summaries of the interview content at the conclusion of each interview for verification. All the interviews were transcribed verbatim, and the transcriptions were confirmed by the participants. Furthermore, all interview transcriptions were checked by the investigators by re-listening to each audio-recorded interview.

Procedures of Thematic Analyses

Thematic approach was used for data analyses, as themes were only identified when they were directly related to the research question. Investigators were open to new, non-anticipated ideas and concepts that were provided (Joffe, 2012a, 2012b). Moreover, the themes that were selected were "semantic" rather than "latent", as greater reliance was placed on the explicit meanings of the data. Thematic analysis was a recursive and iterative process of moving backward and forward between the raw data collected during the interviews, codes, and themes (Braun & Clarke, 2006). To maximize the rigor of the analytical process, the collected data were analyzed by applying major elements of the thematic analysis protocol through six steps: Familiarization with the data; generating initial codes; searching for themes; reviewing themes; defining and naming themes; and producing the report. Two investigators were involved in the analysis. Data from each block of nine participants were analyzed by each investigator. Then, group analytic sessions were held to compare the analyses and to discuss any differences and concluded after the investigators reached agreement on how to resolve any differences in the analyses.

Results

Analyses of interview data revealed 12 themes: Three themes in early childhood, 3 themes in upper elementary and middle school, 5 themes at the SSTRHS, and 1 theme in college periods (See Figure 1).

Table 3. Interview Questions.

Categories	Questions
Recognition of giftedness	•What was the talent domain or interest area that you remember that you displayed first? •When was it? Was there a critical moment when you recognized your talent? •Which experiences in your life were the most contributing factors for the development of your interest or your talent?
School life	•At the SSRHS, what helped you to mature the most? •What was the biggest challenge at the SSRHS and how did you cope with the challenge? •What was the aspect that you paid the most attention to at the SSRHS (for example, what was your first priority in your time management at the SSRHS, research, grade point average (GPA), or project?) •Please describe characteristics of instruction at your SSRHS? •What was your relationship with teachers? •What was your relationship with your peers? •Do you think your learning experiences at the SSRHS were useful for your talent development?
Achievement	•What was the most highly achieved area during your study at the SSRHS? •What was the most meaningful achievement while you studied at the SSRHS?
Career choice	•What was the most important criterion for your college major choice? •What is your plan for your future career?
Life outside of school	•Did you get private tutoring while you attended the SSRHS? (Did you go to cram schools? Which subjects did you take at the cram school and for how many hours a week? Are you satisfied with teaching instruction at the cram school? •What were the most meaningful activities that you did outside of school (e.g., church activities, club activities)?

Stage 1. Early Childhood

Theme 1-1. Early Recognition of Superior Math Talent by Parents. Eight out of nine participants, except S9, indicated their talents in mathematics and/or science were recognized very early by parents before they entered elementary schools. Four participants mentioned parents recognized their talent in science as well.

> My parents used to tell me often that I showed talent in math when I was young (S8, 2019).

> My family never knew about my talent. I played outside until 9 pm every day. Only in Grade 6, I got an award in the math competition. That was the first time for us to realize my talent in math (S9, 2019).

Theme 1-2 Joy of Playing with Numbers and Reading. They liked numbers and enjoyed playing with numbers when they were young.

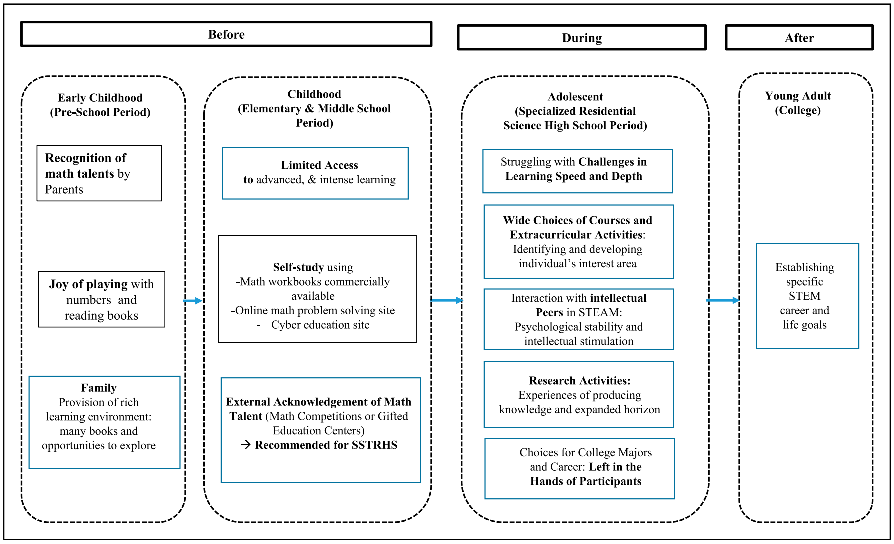

Figure 1. Conceptual Framework of STEM Talent Recognition and Development of Economically Disadvantaged Gifted students

> I liked numbers so much… when I was very young…. about four or five years old, I made numbers with straws or played numbers made out of sponges. … I read many books. Sometimes I read 50 children's books a day (S1, 2019).

> My parents said I liked mathematics very much and they thought I might probably be talented in math (S3, 2019).

> Since I was very young, I was very interested in numbers (S8, 2019).

Theme 1-3: Parent's Support through Rich Learning Environments. During the early childhood period, parents provided them with rich learning environments by taking them to libraries and supplying them with many books or opportunities to explore various activities.

> We had so many books at home. All three sides of the rooms were filled with only children's books (S1, 2019).

> My parents took me to many places. I read many books, since my parents took me to libraries consistently. We chose books and read books together (S5, 2019).

> My father always played with us whenever possible with many different things (S9, 2019).

Stage 2. Elementary and Middle School Periods

Theme 2-1: Limited Access to Advanced and Intense Learning during Elementary and Middle School Periods. In South Korea, there have been no self-contained gifted education classes or schools in elementary and middle schools. There were only Saturday Gifted Education

Centers (SGEC) where only S2 and S4 attended. Most participants did not find appropriate educational opportunities.

> I tried to attend a cram school for three (3) months in Grade 6 and two (2) months in Grade 7. I found it was not my thing, so I stopped (S1, 2019).

> Many of my high school classmates studied accelerated math at cram schools (located in Daechidong of Seoul City). I did not. I should have. So, it was very hard to follow the high school curriculum in the first year (S2, 2019).

> Some of my high school friends had studied accelerated math through private tutoring since when they were in grade 4 or 5 to prepare for Math competitions such as International Olympiad. At least, many of them attended such cram schools from grade 7. I attended regular cram school for three months (S4, 2019).

> Before SSTRHS, I attended a cram school for three (3) months to get some information on how to prepare for admission (S5, May, 2019).

> During elementary and middle school periods, I never attended cram schools and there was no other place to learn happily (S9, 2019).

Unlike many other Korean gifted students, participants attended inexpensive regular cram schools briefly. Probably because these private tutoring programs cost high. Daechidong is an affluent area in Seoul and known for expensive cram schools for accelerated programs for advanced learners.

Theme 2-2. Self-Study. Participants were not guided for learning advanced or enriched mathematics programs. While their affluent peers at the SSTRHS attended cram schools, participants had to search for advanced or enriched math problems by themselves from commercially available math workbooks (S3, S4, S5, & S9), online mathematics problem solving sites (S1), or online programs offered by school district (S4).

> Then, I studied alone at home using problems at the Art of Problem-Solving Math (AOPS) site. AOPS math problems required a lot of thinking, and it was fun to solve them (S1, 2019).

> I generally solved math problems found in the commercially available math workbooks alone. For science, I generally read books widely (S5, 2019).

Theme 2-3 External Acknowledgement of Talent Through Competitions or Gifted Education Centers. Mathematical talent of all participants was acknowledged through various competitions beginning at different grades from Grade 2 to 8. However, only two of the 9 participants attended SGEC, where a total enrollment of the cohort at SGEC in 2016 was 18,042 (NSGIS, 2022). Considering the large number of students at SGEC, the ratio of participants who attended gifted education centers was quite low. This implies that most of these low-income parents were less informed of the existence of SGEC. External acknowledgement increased their motivation for STEM learning and brought them opportunities to be recommended for SSTRHS.

> I thought that I might have talent in math. When I participated in a math competition in second grade, I did not study a lot, but I got a copper medal (S1, 2019).
>
> I was admitted to the math gifted education center when I was in Grades 3 and 4. Then, I started studying a lot more from then on (S2, 2020).
>
> In Grade 6, I got an award in the math competition. Then, I started studying harder. I participated in the science experiment competition and got second place. Then, I prepared for another competition on and on (S9, 2019).

Stage 3. During SSTRHS

They struggled in a competitive atmosphere in SSTRHS but survived by interacting with peers through research or extracurricular activities. They developed good peer relationships and opportunities to network with math and science experts. Their experiences in the SSTRHS were categorized into five sub-themes.

Theme 3-1 Struggle with its Challenging STEM Curriculum at the SSTRHS. All participants struggled in catching up accelerated mathematics curriculum with SSTRHS peers who were far more advanced. To improve their GPA in mathematics, S3, S4, and S9 received private tutoring during vacation time or on weekends with or without actual effecting on improving their GPAs. S1 invested more time on International Math Olympiad or math research rather than focusing on school math, which required speedier solutions for simpler problems. All participants, except S1, increased time for studying school math and it helped GPA improvement. Their math GPAs stayed the same or improved. S1 and S4 lost interest in studying school mathematics.

> I did not like mathematics anymore since my grades were not as high as they had been. The curriculum at the SSTRHS was so much advanced, it was hard for me to follow (S4, 2019).
>
> The most difficult thing was low GPA. I worked hard to resolve the issue. I could not cope with it perfectly. However, it became much better (S5, 2019).
>
> Physics and chemistry at the SSTRHS were at college level. It was so unfamiliar and difficult for me to learn the college level physics and chemistry. Fortunately, most of my classmates were so advanced and helped me when I needed help (S8, 2019).
>
> Since my learning was not advanced enough, it was very hard. The most stressful thing was that all my classmates were bright and available study time was only so much. I studied by myself sitting on the toilet at night not to disturb my roommate. I was so proud of myself when I became the best student in the school one year later (S9, 2019).

Theme 3-2: Wide Choices of Courses and Extracurricular Activities. Participants were provided with wide choices of courses in STEAM and extracurricular activities with peers in music, arts, and humanities. Participants could choose what they wanted to take. These choices helped them to find their niche. Through a wide array of extracurricular activities, they could develop creative thinking. They also developed a sense of responsibility and collaboration with team members.

> We had lots of free time. So, I could devote my free time to extracurricular activities….. I learned to work with others and developed responsibility and collaboration. This is what I did not experience before (S6, 2019).

> It was great to find so many choices of courses. My school tried to offer as many courses as possible. It was great to learn about humanities, art, and creative activities. Also, I really enjoyed project week when we worked on projects without classes (S9, 2019).

Theme 3-3: Interactions with Intellectual Peers. All participants were satisfied with their life at SSTRHS, especially because of their intellectual peers. Some participants did not have good peer relationships in the beginning(S1). However, even these students' peer relationships got better as they advanced into the senior years. Through interactions with peers who were excellent in various fields, they found their perspectives were expanded. They matured and became modest. They self-reflected their negative attitude toward their less capable peers at middle schools.

> When I was attending middle school, I caused trouble. Here, I have many good friends …… I can ask questions, share ideas, and study together (S1, 2019).

> I thought I was a genius in middle school. Frankly, I looked down on my friends thinking 'Why can't they solve it?" At the SSTRHS, I came to know. Ah! Their (my middle school friends') feelings must have been like this (here) (S2, 2020).

> But, at SSTRHS, I was so happy to meet friends who share the same value or goal. Meeting friends who were from different environments and sharing experiences have widened my world view or value system (S5, 2020).

> In retrospect, collaboration with peers helped us to come up with new ideas, whereas work by myself has no way to get help from others (S6, 2019).

Theme 3-4: Intense Research Activities. The curriculum at SSTRHS required students to conduct a year-long research project on real-life problems. Students could also take initiatives to conduct more research projects with their peers, teachers, or external professionals outside of their regular curriculum. Most of the participants felt so immersed in and could comprehend the topic more deeply, and grew as researchers. Even if the research may not have produced high quality products, their research experiences were still useful for a future career.

> I think research is the most important thing at SSTRHS. …I devoted my time on improving 3D printer materials. My research got third place at Samsung Human Tech (competition) (S2, 2020).

> Research activities were most meaningful to me…. Research experiences would be very helpful for my future career (S4, 2020).

> I have a vivid memory of when I immersed myself in research. It was one week before the final exam. I stayed up through several nights with my research pal working in the lab. Finally, we got the expected results. What a sense of achievement and immersion!! (S8, 2019).

> We did a year-long research project. In the beginning, I was not enthusiastic. However, working on it for one full year, you've got to love it (laughter). Selecting a research topic, and eventually completing it, it felt so fulfilling (S5, 2019).

In contrast, some students struggled with research activities. They did not enjoy inquiry-based instruction and research much due to limited foundational knowledge and skills.

> I always felt I had limited knowledge and skills to carry out research projects well. I barely managed to submit project reports. I had conflict in investing my time between GPA and research. I chose GPA to make myself more advantageous for admission to the university (S3, 2019).

Theme 3-5: Choices for College Majors and Career: Left in the Hands of Participants. From middle school period, all parents of participants left choices of colleges and careers in the hands of participants. It could be from their respect for their children's decision-making capability or from the limited insider knowledge on the colleges or career choices to guide them.

> Whatever I wanted to do, they (my parents) supported them (all my decisions) unless clearly wrong (S1, 2019). I was not admitted to the university of my first choice, because I generally worked on competitions and Olympiads (rather than school math). If I had better guides on the college admission, I could have been admitted (S1, 2020).

> My parents were very interested in what I was doing. However, they never intervened (S2, 2019).

> They seemed to hope that I could do well by choosing what I liked. Sometimes they wanted to give me some advice, but there are areas that they did not know well. So, they were rooting for me just because (S3, 2019).

> My parents never forced me to do what they want or like. They used to tell me "First priority is, always, what you want to do" (S8, 2019).

Stage 4. Young Adult

Theme 4-1: Establishing Specific STEM Career and Life Goals. As freshmen in college, all the participants except S4 already established their specific goals such as pursuing Ph.D. in STEM and to be experts in STEAM.

> My goal is to be a mathematician who contributes to human welfare….. I may need to be a professor to support myself financially (S1, 2020).

> I want to do research to find solutions for hunger problems, even if I cannot solve them completely (S2, 2019).

> I want to be a professional. Computer engineering sounds attractive. Chemistry may not be a problem either (S7, 2019).

> I might be able to do great research after my Ph.D. I want to study abroad, like MIT. While visiting MIT, I had a chance to learn about their projects which sounded so great (S9, 2019).

Unlike the other students, S4, whose GPA was the lowest among participants, was concerned about his family's financial hardship and tried to find a path which might free his family from financial burden.

> Studying to get a doctoral degree may add financial burden to my family. By taking high level civil service exam, I may be able to use my expertise in STEM, for example, working at the Korean Meteorological Administration (S4, 2020).

Conclusion and Limitations

This study revealed that the STEM talents of EDGS were recognized early, mostly by parents and acknowledged through competitions. However, seven participants did not participate in gifted education program before SSTRHS, even though SGEC existed for students from Grade 3. Considering early start of STEM talent domain (Subotnik, et al., 2011), limited access to advanced and intense learning and self-study without professional guide might have been detrimental to their talent development (Finn & Northern, 2018; Siegle et al., 2016; Subotnik, et al., 2011). Parents were supportive as much as they could when participants were in early childhood. However, during the upper elementary and middle school period, parents could not overcome the barriers for access to the accelerated and intense learning which was generally provided at the GSEC or expensive cram schools due to their limited finance and insider knowledge. In the beginning of their study at SSTRHS, they struggled with low math grades. However, most of them took challenges and coped with them except one participant. Some soon found their own niche, such as the Math Olympiad or Science Research. With intellectual peers, they were satisfied with life at SSTRHS. Research experiences at the SSTRHS were the most positively influential for them to find meaning of studying at SSTRHS and to pursue STEM career. They were proud of being able to prove themselves as they could successfully adjust to the challenging educational programs at the SSTRHS and even improved to be a top student. They were all admitted to prestigious colleges, even if not their first choice, and their career goals were specific to be research scientists, except S4 whose GPAs in SSTRHS were not high and family was under difficult financial situation. These participants could never have been admitted to SSTRHS without preferential admission policy. However, through preferential admission, EDGS could get benefit from advanced and intense STEM learning and establish specific STEM career goals already in their first-year in college.

Through these themes, four catalysts for talent development emerged and supported findings from previous studies: (1) Family's provision of rich learning environment when young (Bloom, 1985; Cho & Campbell, 2011; Cho & Lin, 2011; Subotnik et al., 2011) (2) external acknowledgements (Nokelainen et al., 2007); (3) intellectual peers at SSTRHS (Almarode et al., 2014; Finn & Northern, 2018); and (4) research experiences at SSTRHS (Almarode et al., 2014). Parents' contributions to talent development were limited to the early childhood period. From upper elementary school period, parents contributed little to their STEM talent development. External acknowledgement compensated parents' limitations in paving paths for talent development. At the SSTRHS, they struggled with weak knowledge and skills in the beginning. However, their intellectual peers helped them to be successful in adjusting to school life. Intellectual peers were both their competitors and friends. Participants attributed their success at SSTRHS to the interaction with intellectual peers who shared similar interests and information and ideas.

While they continue strengthening their knowledge and skills, they started experiencing research activities with teachers, peers and external experts. These research activities were reported as very helpful for the majority of EDGS to choose their majors with confidence (Ziegler & Heller, 2000).

Three deterrents emerged: (1) late start of systematic intervention despite early recognition of talent resulting in less dosage of STEM learning before entering a SSTRHS; (2) parents' limited insider knowledge; and (3) combination of lower grades and family's extreme financial challenges. These three deterrents are inter-related. Families' limited financial capacity hinders them from being informed of and providing their children with special private tutoring. This resulted in less dosage of STEM learning, which was critical steppingstone for successful learning at the SSTRHS (Ziegler & Heller, 2000). From middle school on, parents left choices of learning STEM, college and career to their children's hands probably due to their limited insider knowledge (Subotnik et al., 2011). Parents' advice was to choose what participants like to do. But, "There were some areas they did not know well".

High school level intervention for EDGS deemed to be effective enough for them to pursue to become research scientists in the future. Their achievement gaps were narrowed down at SSTRHS. Through a provision of opportunities, they could excel (Borland & Wright, 1994; Finn & Northern, 2018; Olszewski-Kubilius & Clarenbach, 2012; Yang et al., 2021).

This study was limited in terms of the number of participants due to the required specific nature of eligibility. But the significance of this can be found from its rarity of the study and possibility of adding knowledge on the processes of STEAM talent recognition and the positive development of the EDGS. The last interview was conducted in the first year of college. Therefore, there should be a follow-up study to find more about catalysts and deterrents during the college and later period.

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