ELITE MATHEMATICS STUDENTS IN FINLAND AND WASHINGTON: ACCESS, COLLABORATION, AND HIERARCHY

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This paper draws from a small scale study of elite mathematics students' beliefs, motivations and access in Finland and Washington State. In particular, students' experiences with extracurricular mathematics, collaborative learning, and their elite peer groups are examined.

INTRODUCTION: FINLAND, WASHINGTON AND ELITE MATHEMATICS

Large scale international comparisons exert seemingly unavoidable influence on educational systems. Such numerical comparisons of performance are often read as competitions; the results become lists of winners and losers, focusing attention on the high-scoring educational systems. However, even if large scale international comparisons can tell us where to look, they cannot tell us what to look for.

Within Mathematics and Science education, Finland has recently drawn such attention for its success in the PISA studies. One of the most striking features of the Finnish educational system is the lack of tracking, or separating students according to perceived ability, until the end of lower secondary (*yläaste*), at roughly age fifteen or sixteen. This has drawn the attention of de-tracking reformers (see e.g. Oakes, 2008).

While the efficacy of tracking has been questioned (e.g. Rothenberg, McDermott & Martin, 1998 or Boaler, 2002), de-tracking may have negative consequences for high -achieving students (Terwell, 2005, p. 663). In this paper, I focus on those students who would be expected to benefit most from tracking: students enrolled in the highest possible track available, whom I call *elite mathematics students*. In Finland, these students have enrolled in an academic upper secondary, and then in Long Mathematics (*pitkä matematiikka*) instead of Short (*lyhyt matematiikka*). In Washington, where tracking may begin as early as third grade (age 8 or 9) these students are taking courses classified as Honours, Advanced Placement (AP), or International Baccalaureate (IB). All would reach at least Calculus by graduation.

Participation in elite tracks has been shown to have lasting negative effects on students' mathematical self-concepts (e.g. Marsh, Trautwein, & Lüdtke, 2007), best known as big-fish-little-pond effect. Structure, then, seems to effect the development of students' beliefs and identities as mathematics learners, influencing students' academic decisions. It seems worthwhile, then, to ask how elite mathematics students' identities and beliefs, as well as opportunities to learn within a partially de-tracked system, Finland, compare to those of students in a heavily tracked system, Washington State [1]. Osborn (2004, p. 265) cautions against the "...growing tendency to `borrow' educational policies and practices from one national setting where they appear to be effective and to attempt to transplant these into another, with little regard for the potential significance of the cultural context..." The object of this

study, however, is not to set policy, but to illuminate, through the juxtaposition of two systems, features of each.

RESEARCH DESIGN

The research described in this paper was a small scale study designed to explore elite mathematics students' identities, beliefs, and access to learning in Finland and Washington State conducted with the help of Jasu Markkanen from the University of Turku. The study consisted of 13 student interviews conducted in Spring 2008 in Finland and Washington State. Markkanen conducted four interviews (at Päijänne and Keitele). While many themes emerged from these interviews, in this paper, I will briefly focus on three specific questions:

> What extracurricular mathematic experiences have these students had, or had access to?
>
> What are the students' experiences with and views on cooperative learning?
>
> What are students' characterisations of their peer groups, which were cited by participants from both countries as a key benefit of elite mathematics tracks?

These are a combination of prefigured themes and themes that emerged during the interviews. While questionnaires already exist regarding students' beliefs and motivations, (Malmivuori & Pehkonen, 1996), and are being refined to function internationally (Diego-Manecón, Andrews & Op't Eynde, 2007), they are not focused on the particular population of elite mathematic students I wished to examine, hence the need for an exploratory study.

Semi-structured interviews were chosen to allow opportunity for participants to impact the research, while considering the need for some comparability across interviews. Students were intended to be interviewed in pairs, but sometimes were interviewed in groups of three; extra students who turned up for the interviews were not turned away. Paired interviewing was inspired by its use in other studies (Boaler 2008, Evens & Housartt, 2007). The interview schedule was piloted with two Finns and one Washingtonian, all who had studied mathematics at the tertiary level.

When analysing the data I have attempted to consider that '...there are clear dangers in saying that the interviews simply tell us more about the answers of the individual, as this ignores the presence of their interview partner.'(Evens & Houssart, 2007, p. 22). I see the students' words as public statements, at times inspired, supported, or edited by the presence of peers in the interview setting. I also acknowledge that the interviews may also have served as much in constructing or clarifying certain beliefs as in recording them.

The Selection of Cases and Participants

Eisenhardt (1989, p. 537) writes that while "...cases may be chosen randomly, random selection is neither necessary, nor even preferable." Here, I have chosen cases with an eye towards both comparability and capturing a diverse population. These highlighted characteristics of the schools make them more identifiable, and so

to assure anonymity, Finnish and American English pseudonyms have are used for the cities as well as the schools and student-participants. The cities I shall call Jokimaa and Riverview are small metropolitan areas with a similar population (roughly 170 000 people), with higher than average immigration when compared with Finland or Washington at large, and containing at least one university.

From each community I chose one IB school with higher immigrant enrolment, and two schools considered strong in mathematics or mathematics related fields. A fourth school was added in Riverview as described later. In Finland, these schools were:

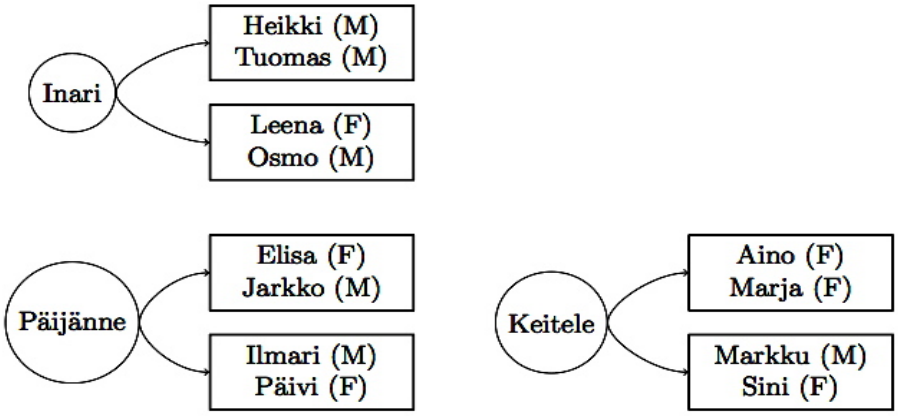

Figure 1: Interview Map for Jokimaa, Finland

Keitele Lukio, known for having a strong and extended mathematics programme

Inari Lukio, an IB programme in an area of high immigration for the Jokimaa area

Päijänne Lukio, offering a special IT line including university level courses

In Washington these schools were:

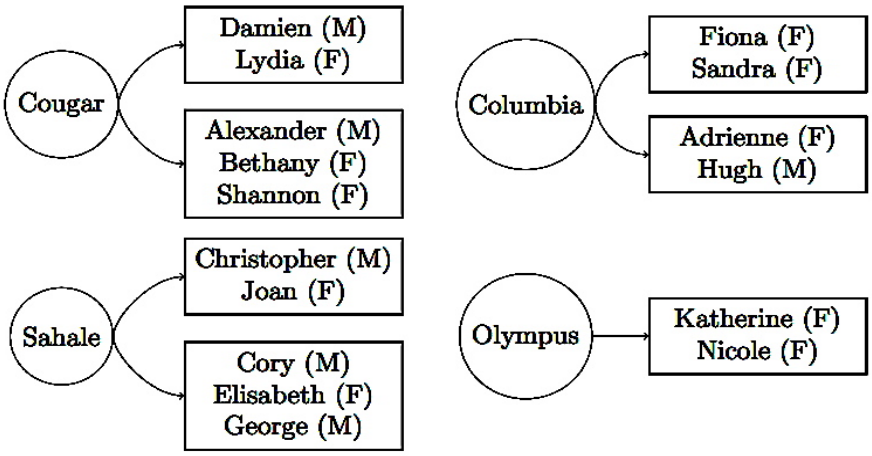

Figure 2: Interview Map for Riverview, Washington

Columbia High, known for strong performance in academic competitions and state exams and offering the most advanced AP mathematics course

Sahale High School, an IB programme with a higher minority enrolment rate

Cougar High is the most affluent high school in Riverview

Students from a fourth school approached me to be included in the study:

Olympus High has the lowest state tests scores, and is majority Latino/Hispanic.

RESULTS FROM THE INTERVIEWS

In this section I will discuss the development of three themes: extracurricular involvement, collaborative learning, and the conceptions of the elite mathematics peer group, first in Finland, then in Washington. The quotes below are selected to illustrate general themes (or exceptions) throughout the interviews.

Jokimaa, Finland: Extracurricular mathematics

Students interviewed from Jokimaa had no experience with extracurricular mathematics besides sitting for an optional national exam. Neither did they seem to be aware of any opportunities such as mathematics clubs. However, when explicitly asked, students did not seem to regret the lack of opportunity:

Saari(JS): Do you think you would have used the opportunity if there'd been some kind of extra-curricular mathematics?

Tuomas: Well, maybe not. [Laughing]

Heikki: [Laughing] To be honest no!

JS: And why, why not?

Heikki: Well, I, uh, value my other leisure activities more, perhaps.

Jokimaa, Finland: Collaborative Learning

Similarly, most Jokimaa students seemed to have little experience with collaborative learning, either formally or informally. For example Äinö said "...usually I've just done things by myself, and haven't cooperated with anyone."

While collaborative learning was described as mostly positive, when there was a mismatch in the level of achievement, it becomes. For example, while Leena enjoys the group work assigned in her IB mathematics course where collaborative work '...benefits, because if you know something and the other one knows something else then you can combine those and maybe understand it better.', she found it frustrating in other contexts, for instance in lower secondary prior to tracking:

Leena: Well, not in that case cause they were the easy problems that I had already solved and other ones asked me all the time that ``how can you do this?'' and stuff and... yeah I didn't like it. [laughs a tiny bit]

JS: Okay, so you didn't really feel like you were getting any academic benefit?

Leena: Yeah, I was just telling them how to do it.

Neither informal nor formal collaborative learning seemed to play a large role in the students' experiences, and perceptions of collaborative learning were ambivalent.

Jokimaa, Finland: Elite Mathematics Peer Groups

Among the students interviewed, the community of peers within elite mathematics courses in Finland was considered a key benefit of the course. Students believed their peers to be more interested and focused on mathematics, and that this enriched the course. For example, from Marja:

> On the Short, there are many people there who study it because they have to, because maths is obligatory, and there is an atmosphere that maths isn't fun, even though there may also be people there who have just wanted to choose short maths [...] it's my experience that on the Long Maths, there are many who really want to invest in the subject and are able to listen during the lesson and all.

Students considered that the nature of the peer group allowed for deeper and more worthwhile content:

> Jarkko: Yeah, I think I sort of feel, like, in principle, when the study group in long mathematics consists of the people who are interested in mathematics, at least, then the environment is easily more pleasing than the short mathematics study group where you can have many people who simply aren't interested in anything mathematical. So it is more encouraging as a study environment, and also in that you get deeper into all the things, you don't- it's like- you can see things as wholes and not only get small bits.
>
> Elisa: Yeah, I actually agree... that at least is an advantage- that those who only take the courses and aren't at all interested, those people aren't there. And that when you have interested people you get to go deeper.

Jokimaa students seemed to emphasise that peers' interest and willingness to learn mathematics was a key asset for their own learning, and a mechanism of selection into elite courses. Students did not portray peer groups as a reason for retention in mathematics. This coincides with Jokimaa students' choice of elite tracks in accordance with future plans, as well as a greater independence from peer and family influence in school and track choice when compared with Riverview.

Riverview, Washington: Extracurricular Mathematics

All of the Riverview students had ample access to mathematics related extracurricular activities and most participated. However, they did not seem to consider involvement as an influential factor in their mathematical careers. One exception was Cory, who had an intention of pursuing mathematics at the tertiary level:

> I feel like I'm almost entirely developed on the outside. Cause like, I have my classes which I kind of just do...like not just do it like C's but I mean, I do and I do good and I um- But like usually I find- cause I don't- I don't know, sometimes I don't feel challenged in a lot of my classes anyways.

Elsewhere, students revealed a lack of real enrichment in these activities, such as when I questioned two of the most accomplished students about a mathematics competition they had been involved in for several years, Math is Cool:

JS: Okay, so, hmm... did you do anything related to number theory?

Sandra: Um.

JS: Have you- have you guys seen-

Sandra: What is number theory?

JS: Well have you seen like modular arithmetic? I'm just curious.

Fiona: Oh! Modu- okay like

Sandra: Yeah

Fiona: Modular arithmetic

JS: I'm not asking you what it is I'm just- just wondering if-

Sandra: Like mod, like that thing, with the dividing?

Fiona, JS: Yeah

Sandra: That's in Math Is Cool.

Fiona: It's in Math Is Cool, like, it's a really challenging- but we don't actually know what it is, just if you give us one simple type of problem with that we'd be able to do.

Sandra: We'd be able to do it. We don't understand it, but we could do it. [Laughs]

While students were exposed to mathematics to which they would otherwise not have had access, it did not often seem to facilitate deeper understanding.

Riverview, Washington: Collaborative Learning

Many of the students interviewed in Riverview had strong collaborative networks outside the classroom. Such students considered these networks crucial in their success and persistence in elite mathematics. Students, such as George and Elizabeth, created lasting partnerships with daily mathematics collaboration.

As in Finland, however, there were students who found the idea of collaboration compelling, but frustrating in practice. For example Adrienne said:

> Well, to teach someone something you have to really understand it, so... you learn it better and you have to remember it more, because you have to figure out exactly what you are talking about before you can help them understand it.

However, her experience was dissonant with this ideal. Again from Adrienne:

> Well, sometimes it's frustrating because I'm not exactly patient, so if a person has trouble understanding something that I think is really obvious then I have to keep trying to find different ways to explain it to them and that's kind of tiresome...

While in general, collaboration was discussed positively, as in the Jokimaa case where there was a mismatch in achievement, actual encounters could be negative.

Collaborations were also limited by hierarchy, which Sandra describes legal terms: `There's like this kid John, who's like the smartest kid, and then we're like the second, legally, or third'. Hierarchy determines collaboration as Fiona says, “It’s more like among the smart people we ask each other questions”.

While intensive collaborations were more evident in Riverview than in Jokimaa, they did not seem to regularly extend past a tight sub-group of peers.

Riverview, Washington: Elite Mathematics Peer Groups

As in Jokimaa, elite mathematics students enjoyed their peer groups, and emphasised that such a community was a strong motivation for staying in elite mathematics tracks. Riverview students also defined themselves against other students in order to explain the benefits of their elite tracks. Here Bethany and Alexander use their experience with a 'regular' or mixed-ability class:

Bethany: And there was- half the people would not care at all, they were just- they- Some of them were just going to drop out of high school right there, but there were some people who actually cared, they wanted to learn what was, the teacher was trying to teach, and as the AP honours classes are introduced, it’s the people who care about what they... get in a high school or want to go to college and need good grades and good classes, those are the people that go on to the AP classes. So instead of being held back by a group of trouble makers-

Alexander: [overlapping] Oh it’s so hard to learn- [laughing]

Bethany : or potential drop outs, [Alexander: sound of disgust]- instead surrounded by people who keep on wanting to learn more who are kind of the driving force of the class, and you’re all about the same level throughout it.

Throughout the interviews, the peer groups’ positive characteristics were a motivation to continue in elite mathematics, and separation from struggling, ill-behaved, or unmotivated students a key benefit. Furthermore, access was believed to be mediated by character. Hard work and desire were the necessary prerequisites, even when students discussed significant parental involvement in track placement.

Nicole and Katherine were the only students who questioned the sorting mechanisms:

Katherine: [It] kind of makes you wonder. [...] It makes you wonder if-

Nicole: The racism is really gone.

Katherine: Yeah. And then you see in your class when you’re a class of almost-

Nicole: Thirty

Katherine: All Caucasian people [In a majority Latino/Hispanic school] talking about Affirmative Action it’s kind of like, how...

However, while questioning the visible sorting at Olympus in several instances, Nicole and Katherine also see access to elite courses as a question of character. Nicole said: “It has a lot to do with work ethic. And if they want to be pushed or if they just wanna breeze right through.”

DISCUSSION AND CONCLUSIONS

There were stark contrasts in access to extracurricular mathematics in Jokimaa and Riverview; Jokimaa students had no opportunities for sustained involvement, whereas Riverview students had diverse choices, and almost all of them had been involved in mathematics related activities. Most Riverview students downplayed the effects of such involvement. However, for at least one student, Cory, involvement was key to his interest and persistence in mathematics.

In Finland, participation in mathematics competitions such as Math Olympiad is used as a signifier of talent (see e.g. Nokelainen, Tiiri, and Merenti-Välimäki, 2002). Yet, the students I interviewed had no access to this, or other, enrichment programmes. So, while PISA finds evidence of equality in Finland's performance, it may be masking inequality of access at the top.

In neither Jokimaa nor Riverview was there evidence of the sort of collaborations described by, for example, Boaler (2008). While collaborative learning is often associated with de-tracking, the Finnish students seemed to have less experience with peer-supported learning. Students from both communities had ambivalent feelings about collaboration where there was a mismatch in achievement. There seems to be room in both communities for further exploration of modern collaborative learning.

For both Jokimaa and Riverview students, an elite group of peers was a positive aspect in mathematics tracking. However, the descriptions used by Riverview students were more hierarchical, and attributed blame to low performing students. Their characterisations seemed close to Sayer's (2005, p. 233) description of belief in the `moral well-orderdness' of the world, where:

> ...[T]he extent to which individuals' lives go well or badly is believed to be a simple reflection of their virtues and vices. It refuses to acknowledge the contingency and moral luck which disrupt such relations arbitrarily.

George said “...it kind of disgusts me to see the people that sit there and just ‘Oh- I have a D in this class and I’m taking Algebra for the fifth time because I don’t do my homework’” That such descriptions seem common among elite mathematics students in Washington, but seemingly not in Finland, is notable. They would arguably be more appropriate in Finland, where there is greater intergenerational class mobility (see Pekkarinen, Uusitalo & Pekkala 2006 or Breen & Jonsson 2005). Furthermore, these themes have resonance with Zevenbergen’s (2005) study of Australian students within a tracking system, where the discussion of classroom ethos and mathematical *habitus* using Bourdieu presents a possible way to deepen future work on this project.

The strong positive characterisations of elite peer groups in both Finland and Washington (also seen in Zevenbergen's (2005) study), and their place in improving learning and retention in elite mathematics, raises questions about how elite students might reply to the big-fish-little-pond concept or the possibility of de-tracking.

Limitations and Conclusions

There are several limitations to this study: more students were interviewed, and interviewed for slightly longer in Riverview, generating richer data from Washington, the linguistic aspects of the research are rough, and there were differences in interview styles between Jasu Markkanen and myself. The students' responses are thoroughly embedded not only in their schools, but their wider communities. However, important reforms, such as universal education and desegregation have involved changes in culture; culture is not fixed.

Regarding elite mathematics students, this study suggests a potential benefit from conducting international comparisons beyond the focus of studies such as PISA. Equality of provision may look different depending on the questions asked, and a comparative lens may clarify where to focus our attention.

NOTES

1. Education is governed mostly on the state level in the US. Washington is a better unit of comparison (than the US) with Finland in terms of population and resources and in addition, recently revised its mathematics curriculum through comparison with Finland, see Plattner (2007).

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