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The construction of the ‘transition problem’ by a group of mathematics lecturers

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This paper presents views of university staff about what has become called the ‘transition problem’ when students start studying mathematics at university. The data are from a focus group interview with eight experienced university lecturers at a Swedish university department that offers mathematics courses for engineering students. We use the portrayal of the problem in the literature as an axis for the discussion.

Keywords: Undergraduate mathematics, lecturers, transition problem, focus group.

DIMENSIONS OF THE ‘TRANSITION PROBLEM’

In some places mathematicians seem to have for a very long time bemoaned a lack of university entrants’ knowledge (Thwaites, 1972); it clearly became an international concern in the 1990’s (ICMI, 1997) as part of a *transition problem*. Based on our reading of the literature, we have grouped the issues mentioned in a range of Swedish and international studies into eight dimensions [1].

(1) *Pass rates and participation:* In Sweden pass rates in undergraduate mathematics courses were at 70% for engineering students at the beginning of the 21st century (HSV, 2005, p. 45). Relatively low pass rates were also reported from other countries (Dieter & Törner, 2010; EC, 2000; De Guzmán, Hodgson, Robert, & Villani, 1998). Further, there is a perceived need to increase participation in higher education of under-represented groups in terms of gender, ethnicity and social class (Pampaka, Williams, & Hutcheson, 2012).

(2) *Alignment of curriculum:* A couple of studies reveal discrepancies between the mathematics faculties’ expectations and the actual school curriculum (e.g., Brandell, Hemmi, & Thunberg, 2008). These relate to

factual knowledge or use of formularies and tables, routine skills or problem solving, and computational fluency or use of technology. Swedish students’ perceptions of their pre-knowledge tend to be more positive than that of their teachers (HSV, 2005, p. 34). Mismatches are also described in other countries (EC, 2000; Hourigan & O’Donoghue, 2007; Hoyles, Newman, & Noss, 2001; Kajander & Lovric, 2005).

(3) *Changes in level of formalisation and abstraction:* Mathematics at university entails specialised technical language, which students perceive as more cumbersome than at school. As depicted in the Swedish report issued by HSV (2005), 75% of the students find mathematics courses difficult, and for 85% the university creates new challenges. In a study in France, Spain and Canada, the tasks were perceived as more “abstract” (De Guzmán et al., 1998). The authors also point out that tertiary mathematics includes “unifying and generalising concepts” (pp. 752–753), often described as a switch from intuitive to formal mathematical thinking or from informal argumentation to mathematical proof (e.g., Brandell et al., 2008).

(4) *Unclear role of mathematics for the students’ career paths:* HSV (2005) reports that only 40% of students in the second semester thought they have made much use of their mathematical knowledge in other subjects. Rather than ‘directly’ useful, students in another Swedish study described mathematics as generic problem solving technology (Bergsten & Jablonka, 2013). De Guzmán and colleagues (1998) see an underestimation of the role of mathematics in a range of subjects in the French, Spanish and Canadian context. A ‘utilitarian trend’, noticed in the UK (Hoyles et al., 2001), can cause conflicting messages as to the purpose of studying ‘pure’ mathematics.

(5) *Differences in teaching and classroom organisation*: In Swedish classrooms one finds a dominance of lessons devoted to individual work scaffolded by the teacher (Skolinspektionen, 2010), providing little experience with the lecture format common at universities where many students point at the increased pace as a characteristic difference to school (HSV, 2005). Similar views are reported by De Guzmán and colleagues (1998, p. 750). Also the character and function of assessment differ (Gueudet, 2008).

(6) *Change in expected learning habits and study organisation*: To study at university requires a higher degree of autonomy than in secondary school (Wingate, 2007; cf. De Guzman et al., 1998). This is also acknowledged by many of the engineering students in Sweden (HSV, 2005). When students' expectations do not match the reality they meet, including a change of the didactic contract (Gueudet, 2008), students can experience stress (Jackson, Pancer, Pratt, & Hunsberger, 2000).

(7) *Differences in atmosphere and sense of belonging*: A university setting with large group lectures increases the social distance between teachers and students, an issue also expressed by Swedish students (HSV, 2005). The anonymity at a large university can be 'quite a frightful experience' (De Guzmán et al., 1998, p. 755). As students often change groups, a sense of belonging cannot be developed as easily as at school.

(8) *Differences in pedagogical awareness and education of teachers*: The image of the university mathematics teachers held by Swedish engineering students is rather positive; while some complaints were raised, a large majority appreciated the engagement as well as the knowledge of their teachers (HSV, 2005). Similar perceptions were revealed in the study by De Guzmán and colleagues (1998). Nardi, Jaworski and Hegedus (2005) describe a spectrum of *pedagogical awareness* among undergraduate mathematics teachers, including four levels labelled as naive and dismissive, intuitive and questioning, reflective and analytic, and confident and articulate (p. 293).

From these studies it is evident that the shifts between the two institutional cultures concern the curricular content, forms of pedagogy as well as the identity of the students as learners of mathematics and as beginning university students. The outcomes of the studies suggest that the shifts of criteria for what counts as mathematics as well as for the appropriate study hab-

its that help the students to acquire this 'new' type of mathematics are often neither coherent nor explicit.

This paper draws on data from a focus group interview to investigate how lecturers who teach first year undergraduate mathematics courses talk about the transition problem, and how their views match the dimensions portrayed in the literature as outlined above. While most previous studies have been framed by curriculum discussions, exam results, or student responses, we hoped that an exploration of the views of experienced lecturers who teach first year mathematics courses at university, may open up dimensions of the transition problem hitherto hidden.

METHODOLOGY

As part of a larger project [2], where around 70 engineering students at two universities in Sweden were followed and interviewed during their first year of study, their lecturers of the mathematics courses at one of these universities were invited to a focus group interview, moderated by one of the authors, to discuss the transition problem. The eight university lecturers/professors of mathematics who volunteered to participate all work at a mathematics department. The audio-recorded session lasted for about 80 minutes and was organised by prompts concerning the beginning mathematics studies at university [3]. As participants knew each other as colleagues and were a homogenous group in terms of their extensive teaching experience and involvement with undergraduate students, we hoped the interaction between them can develop freely into a shared opinion of the group and would also expose issues of disagreements (Morgan, 1997). The participants (L1 to L8 below) were between 40 and 65 years old, one female and seven males. The purpose of the ongoing project and the focus group interview was known to them, and shortly reviewed at the outset.

We used the dimensions of the transition problem as outlined in the literature review as a thematic framework, and indexed parts of the conversation that related to these themes and re-narrated the lecturers' statements. This also helped to identify new dimensions and views that differed from how the transition problem is portrayed in literature. Thus, after discussing some general issues about the focus group interview, some subheadings in the presentation below of our analysis of the interview transcript

relate directly to some of the dimensions from the literature review (indicated by dimension number), while some categorise other topics emphasised by the lecturers. We also looked for expressions of emotions, disagreement and take-up of topics by group members. We believe that there was some interactive synergy in the discussion, which justifies our choice of conducting a focus group.

Our analysis draws on some analytical frameworks that have been used for analysing knowledge in education. Bernstein (1971) sees identity as the subjective, interiorised consequence of a discursive specialisation. This specialisation can for example be that of a pure mathematician, an engineer or an applied mathematician. In a more structuralist interpretation, pedagogic practices are an attempt to shape and distribute forms of consciousness, identity and desire (Bernstein, 2000, p. 203). For the purpose of the study, the concepts of classification and framing that describe the relations between discourses (and groups of actors) and how these are established by distinct pedagogic practices, are of relevance.

THE 'TRANSITION PROBLEM' IN THE EYES OF THE FOCUS GROUP

General framing of the problem

To the opening question about whether there exists a 'transition problem', the answer was unanimously, 'Yes'. Even though the opening prompt of the moderator was not phrased in a way that would essentialise the problem by talking about the 'so-called problem' and 'if there is such a thing', it might have been suggestive; but it did not suggest any specific way to talk about the problem, as, for example, in terms of their own experiences as teachers or in more general terms concerning the structuring of the university courses in relation to conceptions of the school curriculum. The group agreed that it was nothing new, 'This has existed all the time; one talked about this already when I started here as a doctoral student' (L8). Some shared their memories from the student point of view and one lecturer suspected that the problem might have increased in magnitude.

During the discussion the group consistently referred to experiences with their students. The curriculum was taken as a given, although some changes introduced earlier were mentioned. None of them referred to 'us' (as teachers or as an institution) having

a problem. The participants did not phrase this as the students causing a problem for them. Instead they referred to their interpretations of students' knowledge and experiences and gave very specific examples. Only in one episode about marking criteria, the lecturers talked about themselves (in terms of an inclusive 'we'). When referring to students, the participants in most cases talked about 'students' and 'them' or 'one' (indefinite pronoun) as a homogeneous group and occasionally used passive voice (such as 'calculation rules have been forgotten'). In many of their statements, however, three of the lecturers did not generalise to all students, but said 'many students' and occasionally 'some students'. There was agreement in the group that there are many 'good students' who do not have problems with the transition.

A reading of the transcript with attention to individuals showed that none of them seemed to have changed their perception during the session. Also, there was not much evidence of argumentation amongst the group members. This does not entail that they held uniform views about what dimensions the problem consisted, but that they mentioned different aspects and others agreed (often immediately with 'yes, yes') or provided additional examples. Some aspects brought to the discussion by L1 and L2 were picked up by the group and discussed in length. We looked for expressions of strong emotions, but felt there were no indications; most statements were to the point. The lecturers were engaged and eager to contribute and share their views.

Topics and themes

Most of the issues were discussed in contrasting them with what the lecturers knew or suspected about curriculum and pedagogy at school. In one prompt, they were explicitly asked about the differences, where some of the issues mentioned as being problematic were repeated. The problems raised were said to be very common, also among students who later 'show to be very capable' (L1).

Computational facility and problem solving strategies (#2 in the literature review)

Computation appeared as a key word in many statements by the lecturers. What they found lacking in students included general computational facility:

L6: minus signs brackets and such basic stuff can go wrong

L2: the probability that it goes wrong at least once is pretty high if you have to make several computational steps

L5: it is also about being mature ... one can't require at upper secondary that people have the same maturity maybe one needs one semester to level it out

When talking about computation, this was analysed as including both to calculate correctly and to have a strategy. In this context, they mentioned that many students appear not to have learned to think systematically, have no meta-strategies such as a habit to control results, do not know how to work through tasks that include more than one critical step and how to structure a solution when methods are not given:

L8: you get a problem and then you need to adapt .. restate and do things with it before you can get to a point where you can apply that old standard method ... at school this is more direct ... it works to shove that into it directly

The questions students ask in lectures were said to be mostly of the type, 'How did you do that?' that is, more about computational details than about conceptual issues.

Dependency on guidance and instruction (#5 and #6 in the literature review)

The lecturers said that at university students are asked to a much greater extent to approach new problem situations and find out how to use known methods rather than solving tasks by applying given methods, 'you must find out yourself what method to use' (L3). In relation to this requirement, they noticed that

L1: many students don't seem prepared that you may have a good idea and then we try it out and test it to see where it leads
L8: they just sit there if they don't see the whole way ahead they don't start but instead raise the hand and ask

The phenomenon illustrated by these statements had increased, according to the lecturers, and was given much attention in the discussion. Differences in the view of understanding were also raised: at school it means being able to follow the reasoning of others while at university one must do it oneself. One lecturer framed the inactivity of students in the face of more complex problems as a matter of 'maturity':

Organisation and academic study skills (#6 in the literature review)

Other aspects of an observed decrease in expected maturity of new students compared to earlier concerned generally more messy classes, students who do not bring things or return assignments in time, who take teaching for granted as a kind of service, and that as a teacher one must explicitly emphasise how many hours students are expected to work.

Formularies and electronic calculators (#2 in the literature review)

The group also mentioned that the common use of formularies at school creates problems at university where one must have some foundational knowledge available.

L2: we require that they should know some terms ... while at upper secondary it is required that they should know how to find [it in] a dictionary [...] you experience more and more difficulties to learn any ... rule and remember it

Another issue concerned the fact that at this department electronic calculators were not allowed at exams, while at upper secondary they were commonly used, 'that itself is a big step from upper secondary' (L2). This problem was linked to a lack of seeing meaning in mathematical objects that earlier had been available as buttons on a graphic calculator. Students, however, generally did not complain about the change.

L2: the elementary functions sooner or later must acquire some meaning they don't for many students when they come here [...] it's much more common that they complain that they were allowed to use them at upper secondary than that they're not allowed to use them here

Mathematical rigour (#3 in the literature review)

When asked about the differences between school and university mathematics, "rigour most of all" (L8) was mentioned, but when discussing the level of rigour

the participants used in their lectures, it was agreed that such emphasis had decreased:

- L1: much less than before
 L3: you argue for your theorems by examples that make things likely

Nevertheless, how the examples were presented still supported a rigorous approach:

- L2: the reasoning ... the examples they see in lectures there the solutions are as rigorous that they no doubt would pass as solutions [on exams]

The moderator also presented students' solutions to exam tasks, which the participants were asked to mark with the intention to initiate a discussion about the level of rigour they expected from the students. They could not reach full agreement on the accuracy of the presentation in a task they classified as a 'one-point task' (see below) and hence were not sure whether to give it a zero. While one lecturer compared the solution with one to another task and found it 'better', another qualified the discussion as 'nitpicking'. About one solution that contained calculations with approximate values for π and e , they found it unlikely that one of their students had produced it.

Incoherence in students' mathematical knowledge

An effect of the observations that 'a student can be very good at some things but [at the same time] maybe knows nothing at all about other things' (L3), implied that, in contrast to how it was earlier, 'it takes longer time to discover who are really strong' (L8). In the written exam results problems showed themselves through 'lots of simple mistakes' (L6), and that despite the adjustments of the level that had been made, results had generally decreased. However, in topics that were completely new to the students, this effect had not occurred:

- L2: in linear algebra one is not so much disturbed by things one does not remember from upper secondary

Assessment and knowledge criteria (#3, #5 in the literature review)

There was a long discussion about the assessment practice for the written exams. Eventually the discussion revealed well-established practice. One aspect

concerned the organisation of the tasks in written exam papers for summative assessment of the course. In most first and second year mathematics courses these included seven tasks to solve during a given time (commonly four or five hours) with full solutions to be handed in. Each task was marked with 0, 1, 2 or 3 points, where a solution obtaining 2 or 3 points was considered a pass on a task. A common criterion for a pass on the course was to obtain at least three 'pass tasks' and at least 8 points. However, the order of the tasks on the exam paper gave different 'weights' to the points given on each task. In this context, the intention of a task on behalf of the examiner was also critical, as was said after a long discussion about how to mark one specific task:

- L1: if I had been the examiner on this task I would have considered beforehand what I want to test with this task, if I want to test the understanding of graphs yes then maybe this is a task for the upper part of the exam paper and then you can let a way of reasoning pass that we know or ... want to test a rigorous mathematical reasoning then it ends up further down and then there will be no points for the B task

The overall result for the specific student being assessed thus influenced the marking:

- L2: actually we assess the exams the solutions differently if it is about a pass or a pass with distinction ... this we all do a little ... that we set up higher formal requirements for solutions if it is about a pass with distinction

This marking practice was termed 'holistic assessment', as explained by L7:

- L7: if you make a holistic assessment of the whole exam paper and you look at this task in its context and compare to other tasks there are good things in it and pass or not is maybe not decided from this particular one but from a holistic evaluation of the whole paper

When asked whether students would be aware of this practice, one lecturer replied, 'I don't think so' (L2).

However, the holistic approach had been the practice at this department for a long time and several lectures acknowledged that it was somewhat hidden to the students: 'I think not many students know this practice' (L7).

How to overcome the problems

Typical for students who do well is that they work a lot with the course. The formulation that they 'get it' (i.e. the method, the theorem) was used here. It was emphasised, though, that also students with the highest school mark often have a very uneven knowledge base. However, when asked about what positive things they observe today, the group of lecturers agreed about a good 'spirit' in students and that most of them in the end overcome most of the problems pointed out.

- L1: enthusiasm is actually something I think has become better the last years
- L8: when they eventually get going and go through our courses then in the end they do pretty well ... and I don't think we in any way produce worse engineers than we did some years ago ...the end product I think is at least comparable ... even if they maybe had to struggle more on the way

DISCUSSION

Much of what this group of lecturers discussed is implicated in the dimensions of the transition problem as portrayed in the literature. Not mentioned by the group as problematic was the lack of experience of students with the lecture format. As to the differences in teaching, the issue was only discussed in relation to the students' behaviour and not in terms of differences in teachers' pedagogical strategies. Change in expected learning habits and study organisation were touched upon, while differences in atmosphere and a sense of belonging were not discussed. The group focussed on differences in mathematical activities but did not talk about the role of mathematics for the engineering students' careers. Interviewing lecturers allowed for a differentiation of the transition problem and opened up some new dimensions.

The institution aims at introducing their students into a strongly classified (Bernstein, 1971) canon of traditional undergraduate mathematics. The lecturers expected, for example, avoiding inappropriate levels of

approximation and not relying on arguments derived from graphs of functions. They also saw school mathematics as strongly classified (applications and modelling were not mentioned) but different in knowledge structure and pedagogic relation. In addition, they did not differentiate between different groups of students, such as from different engineering programmes.

The lecturers shortly talked about decreasing pass rates, but were not sure about any trend before a member with access to the data reported a decrease. In relation to the performance patterns in the assessments, they mentioned an increased 'incoherence' in the levels of individual students' knowledge. The discussion about the 'holistic assessment' is related to this observation about the increased unpredictability of the students' knowledge. The assessment practice is based on the assumption that there is only one dimension of mathematical competence that amounts to the students' performance. 'It takes longer time to discover who are really strong', reveals an assumption about an essential generic mathematical competence hidden behind a range of more or less virtuoso performances, a form of 'mathematicality'.

The 'pedagogic relation' (Bernstein, 2000) was by the lecturers depicted as one with students who depend on the expertise of their lecturers but even more so on their teachers at school level. In the eyes of the lecturers, the positions made available to the students change substantially: While at school they are constructed as dependant learners who learn how to use a range of techniques with the aid of calculators and formularies but with no authorship in producing some original piece of mathematics, at university they grant the students authorship to create some mathematics through combinations of techniques and mathematical argument as acceptable by academic mathematicians without calculation aids and formularies. This is an apprenticeship into becoming an academic mathematician. Despite the vast majority of the students being from engineering programmes, the lecturers do not conceptualise their teaching as apprenticeship into users of techniques for mathematical modelling in some of their students' future engineering fields.

The focus group came to the unexpected (with respect to the literature) conclusion that overcoming the transition problem is a matter of the students' own work and natural development as they become more ma-

ture and used to studying mathematics at university. They also maintained that the level of competency of the engineers who graduate from the institution has not in any significant sense dropped. As compared to earlier, however, today the students have to 'struggle more on the way'.

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ENDNOTES

1. These only partly overlap with the 'groupings' in De Guzman and colleagues (1998) and Gueudet (2008).
2. The project is funded by the Swedish Research Council; see www.vr.se.
3. These prompts were: Is there a transition problem? How does it show? How common are these 'problems'? How does it show in exam results? How much emphasis is made, in lectures and exams, on the formal aspects of mathematics? How are students informed about the assessment criteria? What type of questions do students ask in lectures? What is typical for students who do well? How does (upper secondary) school mathematics differ from university mathematics? Differences in knowledge criteria? Other issues? What is positive today?