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ATTRITION IN UNIVERSITY PHYSICS

A narrative study of individuals reacting to a collectivist environment

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I wasn't angry because the pace was too high or because I didn't understand it. Then you just think: 'maybe I should study something else.' It's not some-one else's fault.

Abstract

This thesis explores the issues of students prematurely leaving their initially-chosen undergraduate physics programme at a traditional well established research university in Sweden. Attrition from educational programmes has long been an important issue for informing teacher practice, the structuring of the educational environment and for broad educational policy discussions, possibly because high attrition rates are typically assumed to be related to the quality of education. Particularly during the last decade, there has been a focus on the increasingly diminishing number of people choosing to study in a science programme and thus a diminishing representation of scientifically educated individuals across society. Large-scale investigations, such as the Organization for Economic Cooperation and Development's Programme for International Science Assessment, have contributed to a world-wide debate concerning the quality of science education at all educational levels. This thesis, with its focus on the individual in relation to a collectivist environment is a new contribution to this debate.

The thesis is framed using the idea that learning is situated in its context and thus integrally involves social processes. Seven semi-structured interviews were carried out with a group of carefully selected students who had left the undergraduate physics education programme before they graduated. These interviews brought out personal stories around the reasons for them doing so. This data was used to craft a narrative inquiry that was underpinned by the formulation of a Gee-like Discourse model which is characterized in the thesis as the Introspective Discourse model, and which is imbedded in the broader Discourse of, at the least, Scandinavian youth societies. The results show how, by using this Discourse model, some students focus on making sense of their leaving in terms of introspective considerations, such as lack of ability or not being 'meant' to study physics, and draw on little or no reflection on the programme itself.

The analysis provides the basis for a conclusion that a primary reason for students leaving is that they do not conceptualize a legitimacy in voicing problems collectively, and as a consequence are hesitant to engage in collective learning-environments, such as informal study-groups. The reason for this partly lies in a tradition that may inadvertently cause a social separating of so called 'gifted' students from the rest of the student community.

This analysis thus leads to the conjective recommendation for an educational endorsement of the kind of learning opportunities throughout the physics programme which overtly legitimize the collective sharing of each student's different learning experiences.

Contents

Swedish words and phrases

CSN	The Swedish agency that administrates the study support and grants that covers the students living-costs
Folkhögskola	Institution of informal adult education. This type of institution can be found referenced as 'folk high school' in most English-language encyclopaedias.
Fördjupningsspår	Literal translation: 'Absorption track'. A class offered to students who are particularly interested in mathematics.
Fristående kurs	Course offered or taken independently of any programme.
Gymnasium	Three year secondary education, age approximately 16 to 18
Högskola	'New University', formerly the equivalent of a college.
Högstadiet	The last years of primary education, age approximately 14 to 15
Lektioner	Tutorial sessions where you for example do problems from a text-book with the supervision of a graduate student or a member of the faculty.
Nation	Student club. In Uppsala and a few other University towns, every student must join a 'nation', but can choose from a variety of 'nations' – all named after specific geographical areas of Sweden, hence the name.
Naturvetarprogram	Natural science programme
Nollning	The initiating social events held two weeks before the first term starts, intended as optional help for stu-

	dents in forming social relations and feeling at home in the programme.
Teknisk Basår	Technical foundation year: offered to people who lack the formal educational requirements for applying to university programmes in the natural sciences.

Glossary

Constructivism	Believing that the nature of personal knowledge is a web of constructs: Everything learned has to interact with knowledge that was previously learned in some way or another. On the one extreme prior experience acts as empirical foundation for new experience and at the other extreme, prior experience acts as opposition to previous experience. In either case, experience must be personally referenced in order for learning to take place.
Epistemology	When you give an account of 'how you know what you know' you are accounting for your epistemology. For different sets of knowledge, different epistemologies can be applied.
Ethnography	A method of inquiry aimed at understanding and describing aspects of the life, culture and customs of people living or moving in certain pre-defined communities. Originally the method was used in classical anthropology for describing exotic cultures but is now often adopted by social and related studies. (Robson 2002)
Sprezzatura	The quality a person possesses when he or she masters the cultural code-curriculum of a given world – for instance the world of first year physics students at Uppsala University. A more mundane expression for possessing sprezzatura could be 'being cool'. Except, being cool might not be a virtue easily reconciled with, for instance, being a successful physics student. Nevertheless, for an outside observer the analogy holds, while for the in-

sider it can be confusing why the use of the word sprezzatura has its advantages.

Symbolic Violence

'the processes whereby, in all societies, order and social restraint are produced by indirect, cultural mechanisms rather than by direct, coercive social control' (Jenkins 2002, p. 104). Or, Symbolic Violence is the process that makes you fit in where you previously did not, whilst rendering you unable to specify the process you are subject to. A keyword here, in explaining the purpose of symbolic violence is 'reproduction': The reproduction of a culture, a culture that in all sense is arbitrary. This arbitrarity often becomes transparent when qualities and characteristics between two or more cultures are confronted – as could be the case when a person is introduced into a new culture or sub-culture. Had it not been for the stealthy tact of symbolic violence that eases the transition between cultures in making it unnoticeable, introductions would be a hardy process advocated by endless explanations and justifications. Such explanations and justifications could render cultural reproductions meaningless if arbitrary aspects where to be continuously exposed. In short, the mechanism of symbolic violence avoids for everyone dealing with others constantly being required to answer each other's unanswerable 'why?'s.

How to read my qualitative data-representations

In this thesis I have adopted the following conventions:

Narrative constructions:	Regular font, text-blocks are displaced toward the centre of the page. (Note that some narrative constructs are written in a form that resemble the form of verbatim interview transcript – But they are not)
Verbatim interview transcripts:	Italic font, identification of speaker ('I' for interviewer) is followed by the verbatim transcript of what was recorded on the tape-recorder. The text-blocks are displaced towards the centre of the page. (Appendix 3 is a verbatim transcript, but not printed in italics.)
Note:	The convention of the verbatim interview transcript should not be confused with in-text emphasis of selected words, terms and statements which are also printed in italics.

Prologue

As always when I visit Copenhagen, I take the opportunity to see my old friends. This Friday afternoon of February is no exception, except in the story I am going to tell, the friends that I am going to see are my old 'study-buddies' from the institute of physics at the University of Copenhagen.

Before I moved to Uppsala to continue my studies, we had spent a good five years in each others company sharing most of the problems good study-buddies share. We had also spent the best of the early Friday afternoons and the occasional Saturday evening during our days as first and second year physics students at the natural science student-bar called *'Caféen?'*.

Caféen? is a bar for all natural science students, but it also plays the role of a sort of student union. All who are members of this 'union' are allowed into the bar, but for inscrutable reasons the tradition is that only physics students and the stray computer science student become members. Our general assumption, back then, was that the other students did not like physics students, so we just did not like them in return. Where the mathematics students went was of no concern to us and in reality *Caféen?* was the place we went to as physics students to meet other physics students to, during long 'drunk' hours, convince each other that we had a firm grasp of the paradoxes of time travel and other esoteric subjects.

And so, on this Friday afternoon of February, my old study-buddies and I are having an informal reunion at *Caféen?*. Even though we are feeling slightly too old to be here, we are also curious about the scene that we are so used to, but that, because of time, is being played out by different actors. I see all this in Thomas' grin as I enter the almost empty bar and the way that all are huddled up at a table in the far corner under two of the four loudspeakers that ornament the walls of the main room.

After greeting the others, I leave my jacket and suitcase at the table and go to the bar counter where another group of students are hanging out. As opposed to the days when I was a student and frequented the bar, I notice that they now have special drafts. As I am indecisive in choosing a beer, most of the students around the counter get involved in making the choice

for me. Clearly they are all more or less acquainted with the bar personnel. Maybe most of them are bartenders themselves awaiting the beginning of their Friday shift or just hanging out with their friends. I, myself, am acquainted with no-one there.

I finally choose a beer brewed on steamed, roasted and chewed malt and go back to my table to begin the catching up that I had so been looking forward to. Most of it is about the days we ourselves frequented the student bar and how the older students always tried to trick us into doing stuff. For instance the time when we were all ready to purchase new calculators in anticipation of 2nd year's introduction to a new set of spatial numbers we had never heard about before ('the massive numbers; an inference from the topology of the prime number group' that, of course, do not exist). We also remember that usually we took turns buying beers because they were so extremely cheap. So when it is time for the next round we all go to the bar to choose something. We agree that it really does not matter, and that we just want a regular bottled beer – which is what I order. The bartender then opens three bottled strong beers: *Guld Tuborg*. I tell the bartender that this is not what we wanted; but she just looks at me astonished. 'We ordered regular beers,' I say, 'not strong beers.' 'They are regular beers,' she says with a laugh and a toss of her head in the direction of the others, who have maintained their interest in my doings at the bar. 'Here at *Caféen?* a *GT* is a regular beer.'

Slightly annoyed I remember the initiation and its adolescent preoccupation with anything alcoholic. We were all encouraged to drink the strong beer fondly nicknamed '*GT*', rather than the regular beer containing a moderate amount of alcohol.

I take a look at the pricelist on the wall and see that actually they have written up the categories as 'Draft', 'Beer' and 'Light Beer' – no strong beer.

Sure, the bartender indicated with her look that she was playing a joke on me, but I have heard it so often before. I feel slightly too old to be dragged back into being a first year student, but more caustic is my annoyance over her and her friends' acting as if they are the cream of the social layering of physics students, actually believing that they are entitled to decide what I should drink when I visit their student bar. I am also disappointed that they show such a lack of individuality by not even figuring out how to choose another beer, another joke, or at least something that one can recognize as shared values among certain individuals, which is rooted somewhere in the meeting of that and *their* culture. Finally I am slightly ashamed of my feelings of self-righteousness. But really, no-one likes a *GT*

– especially not if it is warm – and this fact is probably the reason for it being served: just as it is fun making a set of unquestioning new students almost go out and buy new calculators for no good reason, it is actually kind of fun that you can make a whole new generation of physics students happily drink something they do not like.

As I said, at this instant I am standing in front of the bar feeling that I am listening to an old joke, but now suddenly played-out on me by students who started one year after I had finished my degree. I give a half-hearted laugh, agree that it must be my mistake, but tell them that nevertheless, I do not like drinking strong beer in the early afternoon, which is why I would appreciate getting a *Grøn Tuborg* – the beer with the regular alcohol percentage. My two companions are also butting in, telling her that a regular beer is what we all want.

Now I see that she is getting annoyed, and she tells me again that, 'You got what you ordered. Here a *GT* is a regular beer.' Clearly she is aware that in the outside world *other* people have another concept of a regular beer, but now that I am on her turf, she is the one who decides.

I am starting to reinterpret her initial laugh and toss of her head towards her 'friends'. To me, she now appears to have enjoyed having me fall into their trap. Even though she did not intend the beer-incident to become an argument she does not intend to budge as push comes to shove. We take our beers and go to our table, grumbling about the impertinence of the whole situation.

Soon another one of the guys notices that the music they are playing appears to be from the same really bad play-list that we had in our day. I go to the bar to ask them to change it. The request is received jovially – they do not like the music either: 'What do you want to hear instead,' a girl on my side of the bar asks. 'I don't know, rock or oldies,' I suggest. She nods and informs the *DJ* that he 'sucks' and that we want to hear rock or golden oldies. When I return to the table the music changes and an *Ibizza* remix of an old Danish folksong is played. It is not any old folksong, but actually the one we sang in the bus when we were going on the 4 day get-to-know-each-other trip somewhere in the countryside. The vocalist has later proclaimed that doing this recording was the one great regret of her life. After this, *Roxette* is played – clearly intended to meet my request for rock. While the volume is raised one of the other guys laughingly says that this tune once became the highlight in a love pursuit of his when he was in gymnasium.

Clearly nothing has changed. I started studying physics almost seven years ago, and now: The same jokes, the same music.

I still wonder what effect a hard-headed culture like the one I met that day would have on newcomers who had just ended a summer thinking they knew what they liked, who they were or who they wanted to become. Would they buy new calculators and drink *GT's* and eventually discover their own foolishness? Would they take the discovery to heart and learn how to be maturely judicious? Or would they become images of their predecessors and with a feeling of righteousness impart the same jokes on their 'behavioural heirs'?

I guess I expected and hoped to find a bit of all three of these. And, on that Friday in February, not such an intense experience of the third.

1 Introduction: Discovering the complexity of attrition

In the prologue, my intention was to capture the essence of my own struggle to find my place as a physics student. I meant to give an illustration of how I have often realized that I was playing the role of both an observer and an actor in a play that I, on the one hand felt was so remote and irrelevant, but on the other hand paradoxically found to be one of the crucial elements of learning and doing physics. What I am talking about is the negotiation of students' socializing standards amongst themselves.

As a student I have seen how other students who always kept to themselves slowly drifted away and finally disappeared from their studies; and I have seen how the really good students realized how they could become even better by just hanging around us mere mortals; studying their own advanced text-books, but occasionally helping us with problems in disciplines that they themselves had long since completed and passed.

Other students' strategies most probably affected my own social attitudes. I have been grouped in laboratories with people I did not know and experienced how difficult it can be to grasp the basic concepts needed for laboratory work when you sit alone in the evenings trying to write your part of the report. I have also had great days in the sun accompanied by my algebra book and too many friends to actually get any real work done. I have left examinations knowing I had failed, alone, without being able to figure out why, and I have left other examinations in despair, but immediately meeting people who pulled me aside to devise strategies for how to pass the re-examination cheering me up and pulling me along.

To be and stay a student I learned that socializing with my peers was my Alfa and Omega and together with others I have asked for help and offered help; assuring that both I and the people around me successfully got through the undergraduate years.

For me socialization and becoming involved was a natural part of my physics studies. Maybe because it felt like a natural part that I successfully completed. I can not imagine having completed if it was not. In an ideal world

everyone who is accepted into a physics programme should succeed. But not all of those who start such a journey, finish it, and physics* is no exception. And this is what this thesis is about: Better understanding students who start studying physics, but do not graduate from that programme. My opening reflection to my thesis work was that maybe some of the students who leave or do not graduate in physics* end up in this position because the socialization aspects I have just talked about did not appear a natural part of their learning experience.

The setting for my study is the undergraduate physics programme at Uppsala University, which in Swedish is called 'Naturvetarprogrammet – Fysik' (which I will henceforth refer to as physics*). For a short description of the physics* programme, see Appendix 1.

This chapter provides the basis for my choice of research strategy for the study described in this thesis. Chapter 2 is an overview of the scientific field in which my study is situated. Chapter 3 is a more specific overview of research that directly informs and is related to my study. Chapter 4 is a description of the method I have used to collect and analyse empirical data. Chapter 5 is a description of my interpretive lens used in Chapter 6 where I present the detailed description of the analysis and the consequent results. Chapter 7 is a conclusive review of the prior chapters. Chapter 8 is a discussion based on the results of this thesis.

But first, some pages about the problem of students leaving physics* as seen by looking at the statistics of a physics* student-population that consists of the people who enrolled in physics* during the period 1997-2002 inclusive. These statistics are the result of a detailed investigation I performed, based on the student records that exist at Uppsala University. The reason that I am presenting my investigation here, before a research question has been formulated, is because the formulation of this question depends on the appreciation that I have come to have during my work, that the issue of students leaving is a more complex and intricate issue than would for example be suggested by those who find gymnasium grades and persistence to be unproblematically correlated.

I will give an overview of the issue of students leaving, what I call attrition, by showing how many students started and how many finished. My primary aim is to establish that attrition from physics* actually is a problem worth treating (and reading about); but also, by comparing grades, sex and progress I aim to justify the research question and methodological over-

view that conclude this chapter and provide the basis for my approach[1] and interpretative lens used in chapters to come. Before proceeding I need to point out that the educational relations that are presented in the eleven Figures that follow in this chapter all have a vertical axis representing percentages of students. In all the Figures these percentages refer to student proportions in the physics* programme 1997-2002 (for each Figure the numbers (n) of students is specified).

1.1 Attrition?

I need to begin this section by introducing the definition of *attrition* that I used for my study. After this I will constitute interpretations of numerical analyses of manifestations of attrition from physics*, with the purpose of establishing an understanding of the extent of attrition vis-à-vis physics*.

1.1.1 Defining attrition

In the context of education research, the term 'attrition' can be substituted for 'students leaving without completion of educational requirements'. It can refer to a course or entire programme. Many go metaphorically further and use the term 'drop out'. But I do not like the term because of its negative connotation: a drop out is by default a failure and whose failure the act of dropping-out is, will always in some sense lead back to the person who is the dropout. I prefer the word 'attrition' because unlike drop out one cannot be an 'attritionist'. In other words since attrition is a collective noun questions around attrition must always be put into a more general setting than that of the individual's. I also like the word because of the etymology hinted at in its definition in the dictionary:

> Noun
> attrition
> 1: wearing or grinding down by friction
> [...]
> 4: the loss of participants during an experiment
> (wiktionary.org 19 April 2007)

In the context of *the problem of attrition from physics**, I will use the following meaning for attrition:

Attrition is a term for students leaving physics* to do something else.

[1] – where the empirical data consists of interviews with students who prematurely left studying physics*. The transcripts from these interviews are presented as rich narratives extended into analytical treatment.

This definition allows the analytic sorting (an axiomatic sorting) of the physics* student cohort into broad groupings of *leavers and changers* and *persisters and graduates*, which is needed for the quantitative relational treatment that I will shortly present. Of course there are times where I will base the grouping of the students on my own intuitive evaluation and it will be clear when I do this. My reasons for doing this, may, for instance, lie in the possibility that some students could have left physics* to continue their physics-studies at another institution. Students categorised in this way were excluded from the analytic sorting described earlier and were instead sorted on the basis of judgements founded on other information available. An example of a student that would otherwise be placed in the *leavers and changers* group is a student who had earned 90 points of course credit and then seemed to have disappeared. A search on the internet then indicated that she had chosen to continue her meteorology-studies elsewhere and therefore did not belong to the category of students who had left or changed their studies (because she had only changed place of study in order to pursue a certain interest).

Another exception might be students who take a break from their studies and return later on in life, or students who had been registered in the programme but had not as yet earned any course-completion points. In such cases I have also ignored my analytic sorting of students into leavers and non-leavers and made other judgements. For example, instances of students that were included in the relational presentations (Figures 1.1 – 1.11) and categorized as *leavers and changers* are those who did not earn any points but had still registered for examinations. Had they not registered for the examinations, I would have removed them from the counting (because some students never show up even though they are officially enrolled).

1.1.2 The extent of attrition

In Sweden, when students pass an examination they receive credit points. One point is awarded for each week of full-time study that is assumed necessary for successful mastery and hence passing of the final examination. A typical standard course in mechanics, for instance, is worth 5 points when passed. (In terms of the European Transfer and Accumulation System (ECTS), 1.5 ECTS points are equivalent to each Swedish point.) To graduate from physics* one needs a total of 160 points, which represents 8 semesters of full-time study (4 years). The points are registered in Uppsala University's electronic registry, called *Uppdok*

When students decide to leave a programme and start in a new programme, the points already earned stay registered as earned during studies

in the previous programme, while points attained within the new programme are then registered as such. Hence any examination of the dossier for a student will reveal if and when they changed programmes within Uppsala University. This information will also include the term and year for each credit registration and, in most cases, even the actual date when the examination was written. Students are encouraged to inform the university if they leave the university prematurely, but in most cases they do not. Since *Uppdok* is not connected to the registries of other universities, if students prematurely move to another institution, this will not appear in *Uppdok*.

Uppsala University finances programmes such as physics* and its associated courses with governmental subsidies. Subsidies are in principle received every time a student registers for a course and earns course-credit points. Therefore no other registration detail of students other than their course and examination registrations are needed in terms of tracking study-activity for accounting purposes – such as would be the case in countries where the cost of education is partly covered by periodic payments from the students.

Swedish students have the option of, and are eligible for, receiving study living-costs grants from governmental authorities. But since this amount is limited to monthly grants for a maximum of 240 weeks it is not uncommon for students to chose to both study and have employment for periods where they do not receive grant money from the state. This means that 'not receiving grant' is not a good indicator of study activity.

Taking all factors into consideration, the only sure sign available to me to indicate that a student had stopped studying was that the student had stopped writing or passing any examinations in the physics* programme. Since student examination-activity is the only data-sign of study activity available, I chose to study student point-attainment for all the students whom had enrolled in physics* during the period 1997 to 2002. I then noted the points each was awarded, if and when they had received a degree, and if and when they had enrolled in another programme at Uppsala University.

Plotting the data for 166 (out of a total of 181) students and their semester-by-semester point-attainments, having put aside the students who had not, to-date, been awarded any points after registration (assuming those to be students who registered, but never actually started studying in the programme), yielded the result shown in Figure 1.1.

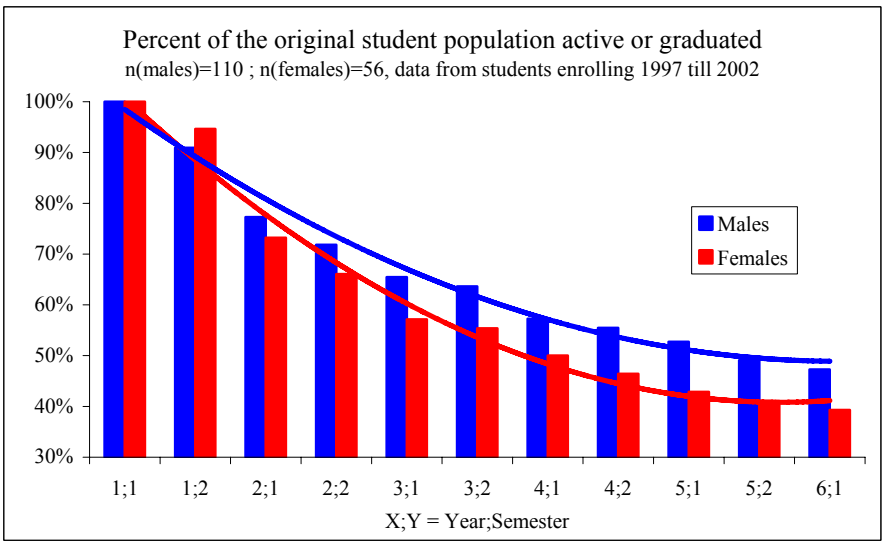

Figure 1.1: The percentage of the original student population that is still active during the first 5½ years after enrolling. The red and blue lines are polygonal approximations for the data.

What may be seen from Figure 1.1 is that approximately half of the males that enrolled, and who have actually taken examinations within physics*, are still active or have at some point in time graduated after 5½ years. In my analysis I have kept the students that at some point graduated as a constant. I did this because these students could relatively safely be assumed to be active students throughout their studies. One can also see that of all the women that enrolled, approximately 40% either graduated or are still active after 5½ years. All in all I have found 71 of the 166 students who started studying physics* during the period 1997-2002 to have either graduated or appeared to still be active students in physics* or active in physics programmes at other institutions.

Consideration of Figure 1.1 also indicates that attrition from physics* is worryingly significant: Only less than half of the students who start their studies go on to complete them and graduate.

1.1.3 The nature of attrition

1.1.3.1 Grades and attrition

In Sweden the need for physics graduates is greater than the perceived student-desire to study physics. This lack of entry competition means that the only requirements for being admitted to physics* are that students need to have passed 90% of their secondary level education curriculum

with credits in natural science courses at a certain level[2]. These relatively 'low' entrance requirements mean that there is a chance that many of the students who enrol barely have an adequate preparation for the learning challenges of a typical undergraduate physics programme (I write this recognising that 'border-line' school grades are not necessarily a good indication of later abilities).

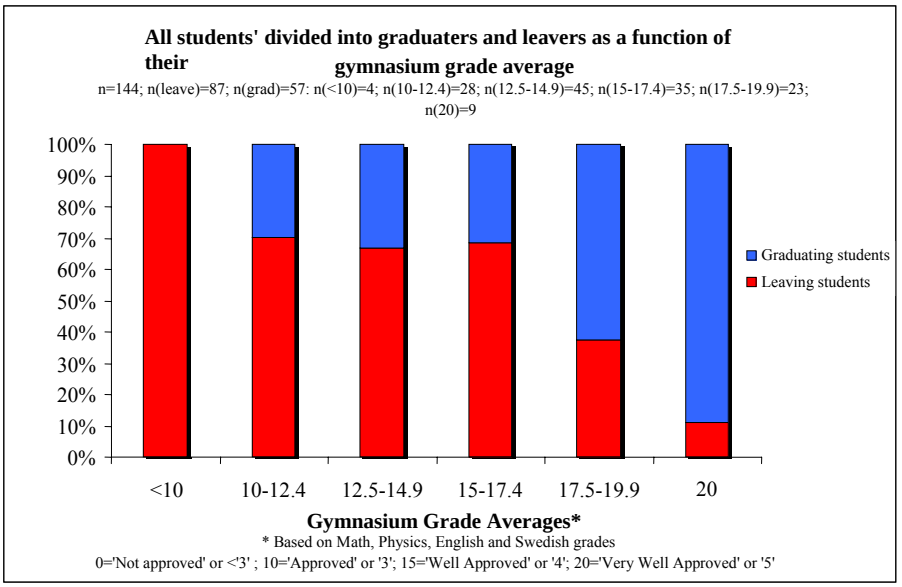

Figure 1.2: The relationship between students leaving and students graduating as a function of gymnasium grades. The vertical axis is percentage of total number of students, 144.

I have based my *grade average*[3] on a selection of grades: Mathematics (at levels C and D), Physics (at levels A and B), English (at levels A and B) and Swedish (at levels A and B). The reason I used this selection, is that they are common for the majority of Swedish secondary – *gymnasium* – level education graduates who apply to the physics* programme, even though the range of secondary education programmes is extensive[4]. The reason that the number of students (n) used in Figure 1.2 differs from the number of students used in Figure 1.1 is that it was not always possible to obtain

[2] This description is an outline of the actual rules that are somewhat more complicated. The actual requirements can be interpreted and applied even more leniently.

[3] *Grade average* should not be confused with *course* points awarded or their average. Grades have their own point system as reflected at the bottom of Figure 1.2.

[4] Currently there are 17 different programmes with centrally defined curricula ranging from the traditional preparatory science programme to for instance the vocational hotel and restaurant programme. All programmes make the graduates eligible for applying to university provided they meet the additional requirements specific for any given university programme. For being accepted into physics*, the applicants also need to have passed physics, mathematics and chemistry at a specific level.

the data on student school grades. Since some students get accepted on grounds other than their grade average I assume that this is the reason that these were not registered.

As can be seen from Figure 1.2 the students who leave physics* mostly come from the lower grade-average group. Note, however that the grades *are* distributed: There *are* a number of students who graduate and who have a low secondary school grade-point average, just as there are students that leave who have a very high secondary education grade average.

An important aspect to note from Figure 1.2 is that there is no big change in the proportion of students who leave until the grade average exceeds 17.4. This means that if a student has a grade average below 17.5, then the probability of this student not finishing his or her studies is *not* noticeably affected by his or her gymnasium grade average. However, if the student has a grade average *lower* than 10 then there is a greater chance that they will leave. While with a grade average above 17.4 the probability of graduating increases in relation to gymnasium grade average.

This discussion suggests a causal link in our understanding of attrition. However, it is important to remember that '*correlation does not necessarily imply causation*'. In other words, just because grades and success are strongly statistically correlated in some way or another, it does not necessarily mean we have found a *causal* link for academic success, only a *predictive* one. While the conjecture that 'gymnasium grades directly provide a causal link to academic success' (e.g., good educational grounding and background) may be correct, there are probably other more important and influential causal links, albeit probably largely covert, which would provide a better understanding and insight of the nature of the cause. For example, two other causal links could be that grades are an indicator of intellectual self-esteem and self-efficacy[5], and that intellectual self-esteem and self-efficacy are better predictors of academic success. Or grades are more an indicator of an ability to conform to institutional requirements than an indication of intellectual ability, and that the capacity to conform predicts academic success. This is why I have not taken the above presentation at face-value and strongly argue that further exploration of these sorts of relations needs to be undertaken, particularly through a qualitative sociocultural lens.

[5] 'People's beliefs about their capabilities to produce designated levels of performance that exercise influence over events that affect their lives. Self-efficacy beliefs determine how people feel, think, motivate themselves and behave. Such beliefs produce these diverse effects through four major processes. They include cognitive, motivational, affective and selection processes.' (Bandura 1994, p. 71).

Now, while the results that I have just presented indicate that secondary education grade average is an indicator of attrition, the important *how* question remains illusive. For example, what about performance in relation to attrition? I will explore this in the next section.

1.1.3.2 Grades and performance

By comparing physics* students' performance (1997̃2002) in terms of grade attainment during the first two years of studies with their total grade average from gymnasium education, I obtained the relationship represented in Figure 1.3.

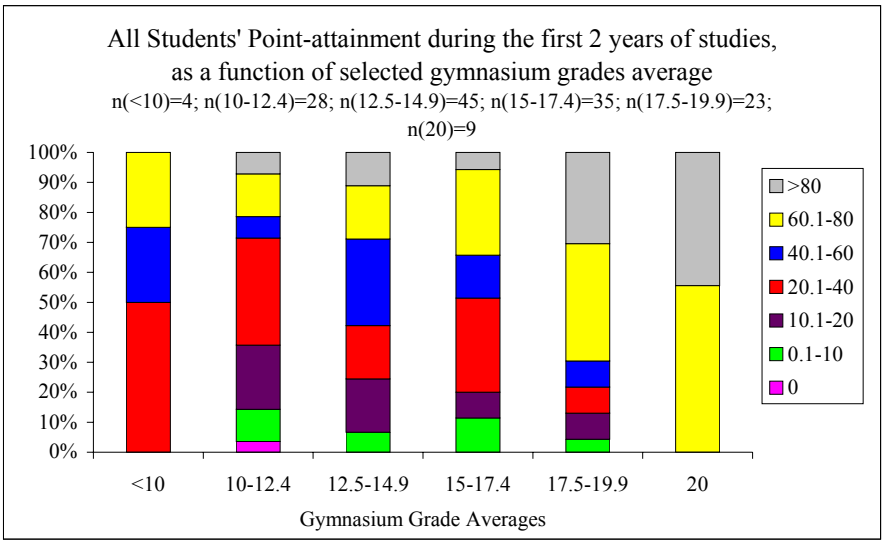

Figure 1.3: In terms of total student-number percentage, the relationship between student performance expressed as course-points attainment during the first two years of study and the students' grade average. Students included here enrolled between 1997 and 2002, inclusive.

There is no doubt that gymnasium grades are correlated with performance measured as point-attainment during the first two years of university study. Again I would like to direct attention to the observation that within the 'acceptable limits' of performance, there is only a very slight difference between those students who had a grade average from 10 and up to 17.4 – plus, there are students of all grade averages who successfully study within and in some cases above the prescribed pace of 20 points per semester. Especially impressive are the 9 students who had a gymnasium grade average of 20 straight – the *straight–20 students*. But it should be noted that more than 20% of the students with even very low grade-averages show a

passing rate within acceptable limits[6]. A factor that might very well influence point-attainment is the fact that students are encouraged to take courses outside of the programme worth up to a maximum of 40 points. Such activity is not included in this analysis, leading to the conjecture that insecure students might be quick to take such courses and thereby appear here as low performing – even though it might not actually be the case. A very definitive conclusion to be drawn from Figure 1.3 is that very high grades are a sure sign of predictable 'staying-power' and success. None of the straight–20 students appear to take courses outside physics* during the first two years of programme study. This might not be that very surprising: Having a really good grade average would guarantee admission into any university programme in Scandinavia. Choosing physics in Uppsala then, might be a very deliberate choice that is reflected in subsequent course-choices.

1.1.3.3 Performance and attrition

This leads me to another question worth posing: Do the students who end up leaving have less self-esteem and self-efficacy (and thus motivation) than students who end up graduating? To search for an insightful answer I divided students who left and students who graduated into two groups and plotted their semester-by-semester point-attainment during the first three years (see Figure 1.4).

[6] Passing courses worth 60 points every second year, will get you through the studies in less than 5½ years. The studies are prescribed to 4 years, but in the governmental grant legislation time is given for 6 years of studies. These additional years could be used studying at a slower pace than the prescribed, or they could be used if changing programme.

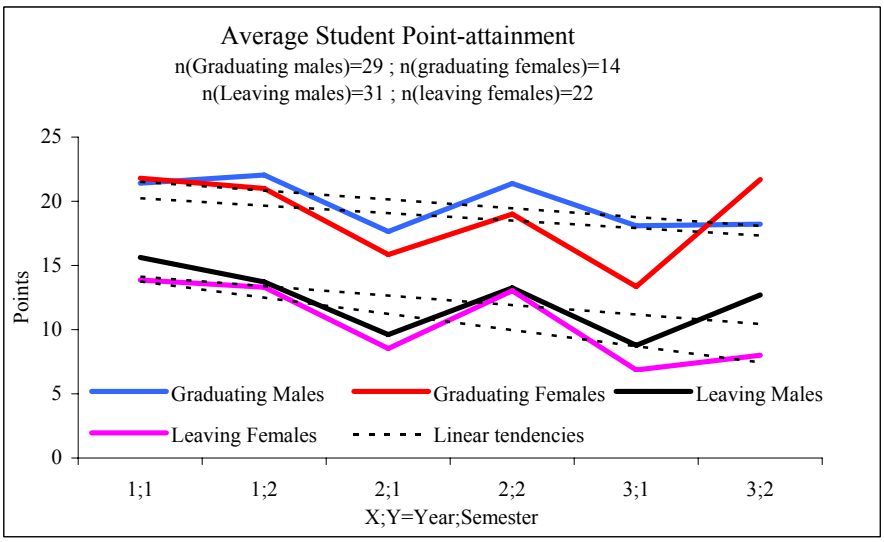

Figure 1.4: Overall student average point-attainment semester-by-semester[7]. Cohort includes students who enrolled between 1999 and 2002.

First of all, Figure 1.4 shows that students who perform well are more likely to graduate, however, these students, who perform well, have a gymnasium grade average spread over the whole spectrum of 10 and above. Secondly, students who leave generally start out producing fewer points than students who graduate do. This might be interpreted as an indication that students who leave are lacking in self-esteem and self-efficacy – insecure about their studies already from the start and therefore more likely to leave.

Another aspect of Figure 1.4, worth commenting on is the somewhat curious tendency for students in average to produce more points in semesters just before the summer vacation (which, without exception was a pattern that showed up for every enrolling student cohorts, year for year). This is in itself no surprise as I defined Autumn and Spring Semesters according to the general definitions, which end with January and August respectively. This means that I have also included the summer-vacation when students are given the possibility of re-taking the examination of courses not passed which were offered in both the Autumn and Spring Semesters. Instead, the surprise is in the explanation for the pattern: It is an indication that

[7] Surely, attaining points is no continuous process as indicated by the choice of representing the data in a line-diagram, but rather an end-of-semester *event*, as would have been indicated clearer by representing the data as a bar-chart. However, I decided on this form in order to better accentuate the difference between spring and autumn point-attainment. An effect that is hard to spot in a bar-chart that tends to get a bit messy when the values for each block of bar-charts differ as much as they do here.

students are consistently re-doing examinations during their summer-vacation, both men and women and both leaving and graduating students alike. Under any circumstances, getting through physics* is not a straightforward question of doing the studies as prescribed – not for the straight–20 students either, viz Figure 1.5.

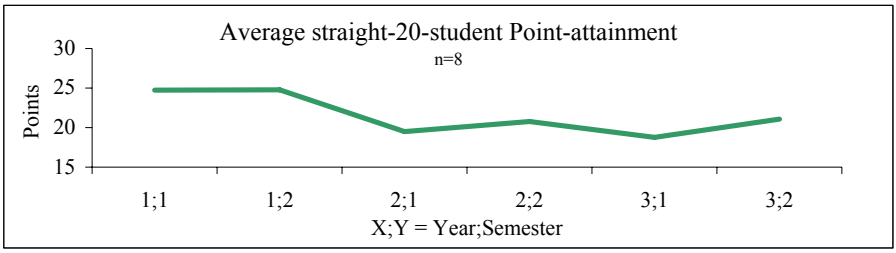

Figure 1.5: The average semester-wise point-attainment for the 8 students who had a secondary education examination average of 20 in Swedish, English, Mathematics and Physics.

Note, that straight–20 students tend to start their studies by taking the equivalent of one extra course during each semester the first year. After the first summer-vacation they seem to 'drop down' to a level of achievement more like the prescribed.

1.1.3.4 Concluding remarks on 'The nature of attrition'

Grades are related to attrition and performance, and performance is related to attrition, but what we see is that performance and attrition only appear to be correlated with the actual grade average if the student either has a grade average below 10 or if the student has a grade average above 17.4. If we only look at students who have a gymnasium grade average in the range 10-17.4 then there are no really discernable correlations to be found.

In the next section I will explore the issue of attrition in relation to biological sex.

1.1.4 Attrition and biological sex

An aspect that I have not, until now, touched upon, is the difference in the attrition rates for men and women.

By counting the total number of students active each semester and extracting the female fraction, the tendency for more women relative to men to leave physics* that is discernible in Figure 1.1 is amplified in Figure 1.6:

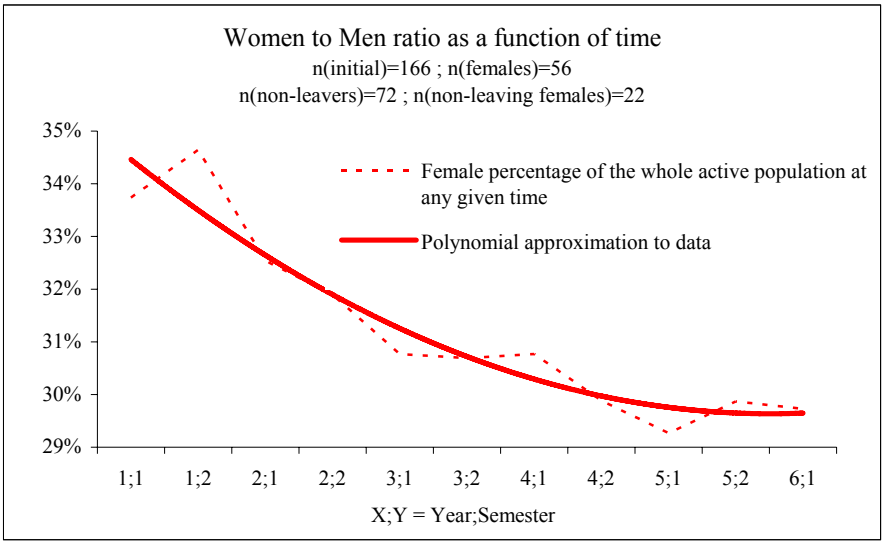

Figure 1.6: Women to men ratio at each semester throughout the first 5½ years of studies. 1997-2002 student cohorts are included. Students that graduate are included as a constant.

What we see in Figure 1.6 is that the low female enrolment-fraction of 35% at study-start becomes even lower as time goes by, ending with a 30% ratio. Especially after the second semester and during the following two years the rate is high (as can be seen by the dotted line that represents a plot of the actual data). Curiously, men are leaving faster than women between the first and second semester, but afterwards the women's relative attrition-rate increases. Note, however that Figure 1.6 is exaggerated. For a more 'frank' representation, I would like to refer back to Figure 1.1.

To explore this issue further, I have broken down the students' gymnasium grade averages into 'language' and 'science' averages in the next section, to see if there is a connection in that way. One could speculate that since women are usually better at languages in school than men are (OECD 2004), the women who start studying physics* might not have appropriate science competencies compared to men.

1.1.4.1 1.1.4.1 A closer look at the gymnasium grades

Having established that those who graduate have a better gymnasium grade-average than those who leave, the next important question that is embedded in this complexity becomes: What about the relationship between attrition and physics and mathematics gymnasium grades relative to gymnasium language grades? The relations in data presentations given in my Figures 1.7 – 1.10 offer insights to this question.

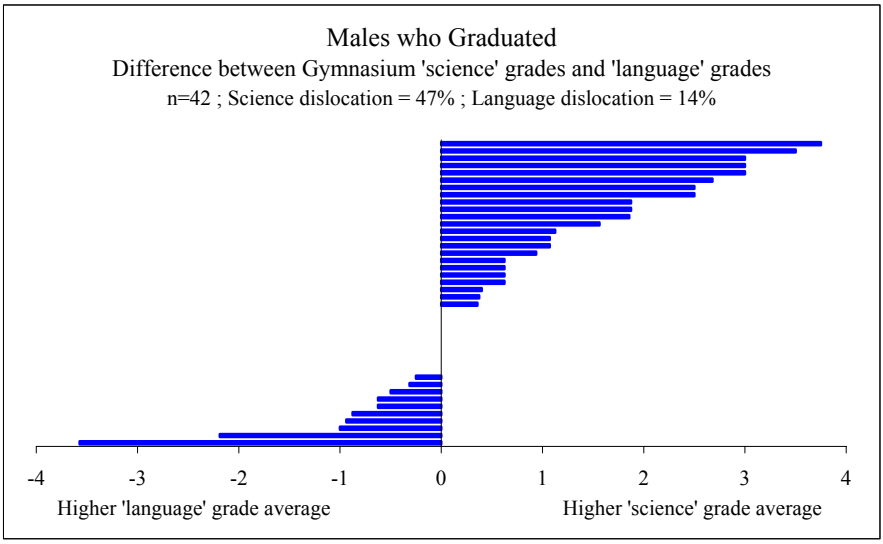

Figure1.7: The science grade-average delta for 42 male students who graduated from physics*: gymnasium-language grade-average subtracted from gymnasium examination grade-average in mathematics and physics. 47% of these students had higher grades in science than in languages and 14% had a higher average in language.

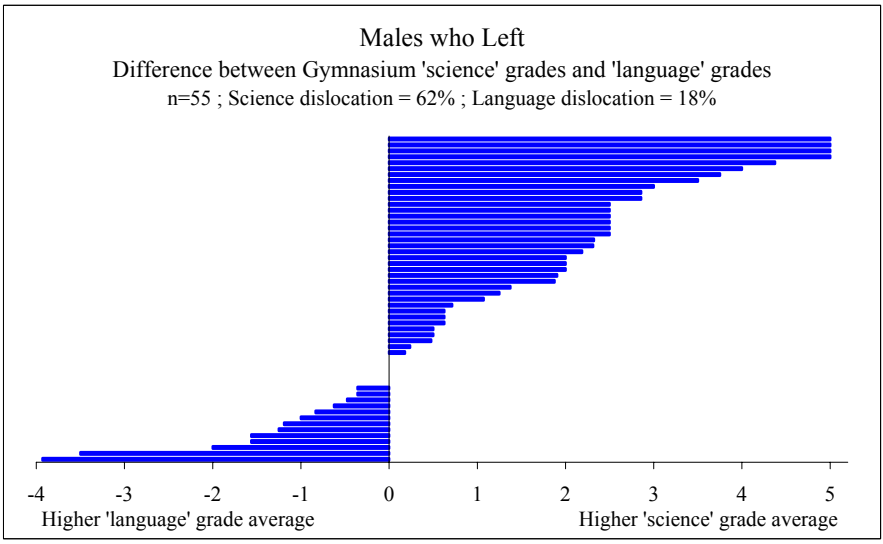

Figure1.8: The science grade-average delta for 55 male students who left physics*: gymnasium language-examination grade-average subtracted from gymnasium examination grade-average in mathematics and physics. 62% of these students had higher grades in science than in languages, and 18% had a higher average in language.

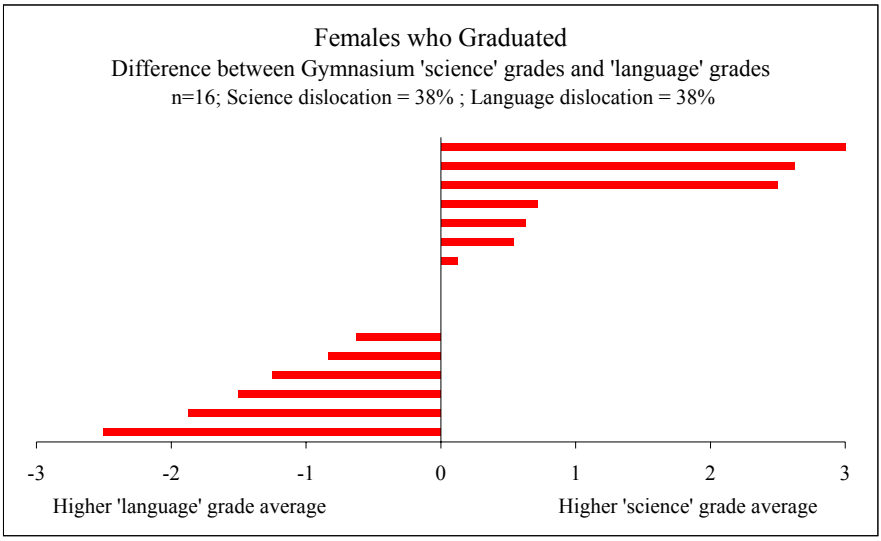

Figure 1.9: The science grade-average delta for 16 female students who graduated from physics*: gymnasium language-examination grade-average subtracted from gymnasium examination grade-average in mathematics and physics. 38% of these students had higher grades in science than in languages, and 38% had a higher language average.

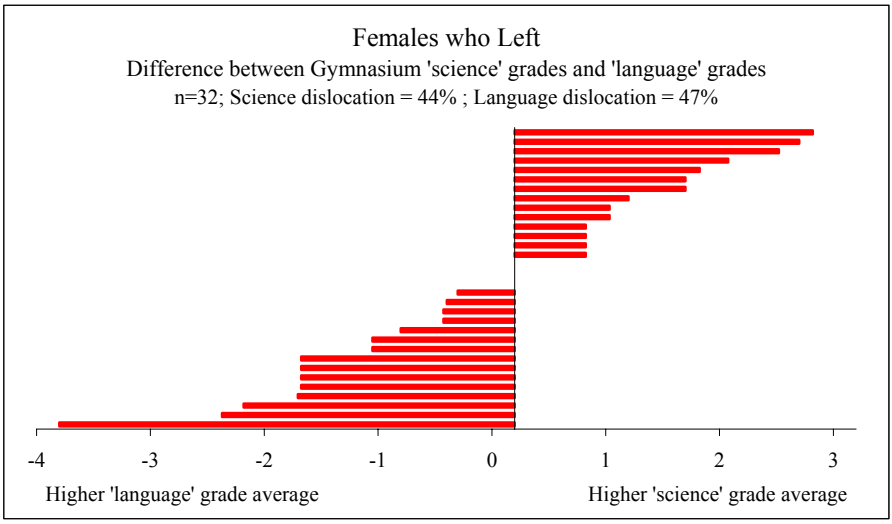

Figure 1.10: The science grade-average delta for 32 female students who left physics*: gymnasium language-examination grade-average subtracted from gymnasium examination grade-average in mathematics and physics. 44% of these students had higher grades in science than in languages, and 47% had a higher language average.

What I find so striking about Figures 1.7 and 1.8 relative to 1.9 and 1.10 is their paired likeness. Both male students who graduated from, and male students who left physics* had, to a large extent, better gymnasium grades in science, than they had in languages. On the other hand, for the two groups of females, those who left and those who graduated are distributed in the same kinds of ways: Some had good grades in science and others have good grades in languages. An argument can thus be made that it seems unlikely that the 'grade-average delta' could be a good predictor of attrition trends. Rather, it might be a predictor in terms of male and female as is already known: (OECD 2004).

1.1.5 Conclusive remarks

In Table 1 I draw out the 'key numbers' from my data-collection as on overview of the quantitative results that I obtained:

	Total	**Men**	**Women**
Students starting physics*, 1997-2002	166	111	55
		(67%)	(33%)
Students leaving physics* (attrition rate)	95	61	34
	(57%)	(55%)	(62%)
Students leaving physics* *and* Uppsala	49	33	16
University	(30%)	(30%)	(29%)

Table 1: Key numbers from my quantitative analysis. The percentages are calculated relative to the category of specific relevance (for instance, the female fraction of 'Students leaving physics* and Uppsala University' is calculated in relation to the female fraction of 'Students starting physics*').

I believe the most noteworthy aspect to draw attention to in Table 1 is the difference in the fraction of men and women who leave physics* compared to the fraction of men and women who leave Uppsala University altogether. As I have already noted, it is impossible to know if the students who leave Uppsala University do so in order to continue their studies at another institution, which is why I cannot say anything about the number of students who leave university education altogether. But what the numbers do tell us, is that physics* is an experience for students that 'turns them off' studies at Uppsala University in equal proportion across men and women, *yet* they also tell us that physics* is an experience that 'turns off' relatively more women than men studying physics*.

I have shown that more than half of the students who start studying physics* do not finish the programme. I have also shown that there may be a connection between students in physics*' gymnasium grades and attrition;

but no consistent connection was identified, and one cannot see from this investigation what the causal relation of such a connection is.

I have shown that over the time period 1997-2002 relatively more women left physics* then men, even though men and women leave Uppsala University in equal proportions; but one cannot see from this investigation why it is so. We can only provide conjectures.

As a relatively safe point of departure, I will infer that the reason for students leaving physics* must be found somewhere in these students' learning experiences related to physics*. This means that I do not find it probable that a significant proportion of students leave because of reasons that are independent of this experience, for example, such as winning a lottery or a sudden serious illness.

Since the pattern of attrition is different for men and for women, I also think it would be relatively safe to refine my reflective conjecturing and speculate further that the explanation lies somewhere in students' experiences related to the *culture* of learning in physics* – what it means to learn in physics*. This means that I find it improbable that aspects of the experience related to academic ability in physics* could account for most of the attrition, for example, such as leaving because it appears impossible to pass the examinations. Departing from these considerations my research question is formulated in the next section.

1.2 Research question

This thesis is an exploration that is informed by thoughts as the above. I think that my conjecture is correct, but arguably perhaps it is an extremely safe guess: I have not specified what aspects of the culture of learning in physics* I refer to, when I posit that students' reasons for leaving may be strongly related to their experiences with the 'culture of learning in physics*'. But it is time to stop guessing, and instead ask for answers.

The complexity that must be bringing out these data patterns led me to decide that further fruitful insight now required a qualitative investigation. Conjecture-reflections around possible explanations for the data patterns I have presented so far are what led me to formulate the research question for this thesis. Inspection of the kind of analysis I have presented so far can only inform us about how things *are*, but do not *why* they are. My research question represents a sociocultural-led start in the exploration of *why*.

When students prematurely leave the physics* programme at a well-established research university in Sweden, what aspects of the culture of learning associated with that physics programme are related to their decision to leave?

To answer this question I chose to build a narrative enquiry drawing on Gee's (2005) notion of a Discourse model. Thus, in the spirit of presenting a 'thick description'[8] background for my qualitative framing, I want to present the frame of mind that I had as I embarked on my self-challenging research endeavour. This I will do in the next section that briefly provides a methodological overview as the last part of my introduction to my research.

1.3 Methodological overview

Describing aspects of culture and social identities are qualitative issues. Qualitative research can be based in multiple theoretical frameworks and on multiple methods, but characteristics for qualitative research differ from quantitative research (my statistical investigation based on student records was an example of the latter). The kind of qualitative research presented in this thesis essentially focuses on gaining rich insights and understandings and to do so often credibly relies on being informed by data in the form of small, but focused samples (cf. Denzin and Lincoln 1994). Thus I selected seven students who left physics* for an in-depth narrative study, informed by a Gee-like (Gee 2005) 'big D' Discourse model.

My frame of mind as I started out into this qualitative research domain was that I passionately believe that education, in principle, should leave room for all kinds of people. Thus I started my research journey reflecting that the answer to my research question *should* be a resounding 'No aspects of the culture of learning physics* made students decide to leave!'

Students need to unite around an interest in the subject-field that they choose to study, and in this need lies a multitude of social identities that cannot 'fit' everybody (as for example those who do not find the subject field interesting, or people who fundamentally object to institutionalizing education). But there is a chance that some of the social identities that students perceive that they need to unite around are not necessary in rela-

[8] For an excellent overview of this term that was introduced by Gilbert Ryle, see Thick Description: Toward an Interpretive Theory of Culture by Clifford Geertz at http://www.iwp.uni-linz.ac.at/lxe/sektktf/gg/GeertzTexts/Thick_Description.htm

tion to a successful learning of physics. However, from the analysis presented earlier in this chapter it is clear that for some reason physics* *does* not, for example, unite a relatively larger fraction of females than males. In principle, there should not be a reason for that. Because women *tend* to be different from men, I would argue that this is an expression of certain kinds of individuals that just happen to be overrepresented amongst women. This means that an aspect of my research-question includes a searching to understand what those social identities are that underpin a leaving-culture of physics* and just happen to be over represented among women. One could approach this question from a gender perspective, but at this stage other work needs to be done, and part of that other work is the work reported on in this thesis. In my thesis I address my research question and the underlying questions of what the social identities are that inhibit a social uniting around physics*. A full methodological overview is given in Chapter 4.

2 Physics Education Research

This thesis contributes to the field of physics education research (PER), that is, research on the teaching and learning of physics at the university level. As such, this chapter gives an introduction to the field of PER and situates this thesis in the field. The chapter should not be read as an historical representation depicting the central works of the field, but rather as a review of literature that represents the crux of a developing field.

PER is a relatively new scientific area that emerged from natural science practitioners' interest in teaching and learning (Redish and Steinberg 1999). To this end, PER is widely accepted as being an integral part of the physics discipline. It is tempting to borrow Kuhn's description of the field of physics as made up of multiple sets of both conflicting and compatible paradigms constituted by disciplinary matrices (Kuhn 1996). From this, PER can be described as a paradigm emerging out of physics, still in the process of constructing one or more tenable disciplinary matrices in which practitioners can engage in the normal scientific work that follows the characterization Kuhn called 'scientific revolutions' (*ibid*, pp. 92-110). Today, PER can at first glance appear as a collection that includes several unrelated topics, and in this section I will describe examples of work done in the field, grouped under certain topics. As we shall see, PER is not necessarily that 'scattered'[9], but differs theoretically on a level that can almost be characterized as ideological.

Along the line of Danielsson's 'how' and 'why' distinction (Danielsson 2007), I will make a rough distinction of PER contributions as either empirically descriptive or theoretically reflective – where empirical work often informs that of the theoretical and vice versa. The next section describes early research done in PER, where the focus was on empirical work done to investigate student difficulties.

[9] The work is published across a wide and diverse collection of journals whose areas include humanities, social science and natural science

2.1 Empirically descriptive works

2.1.1 Identifying and describing student difficulties

From the late 1970's on, much work has been done in identifying and describing student ideas about physics that differ from the accepted scientific ideas. Such ideas are often called misconceptions (see for instance Nuthall 1999), alternative frameworks/conceptions as 'theories-in-action' (see, for example, Driver and Erickson 1983) or pre-(scientific) conceptions. (See, for example, Dijk and Kattmann 2006, who argue for the use of the latter term). In the context of PER literature these terms fundamentally refer to the same idea: knowledge elements that in form and content appear sufficient to the student in explaining and predicting in physical contexts, but differ from the orthodox conceptions of physics practitioners by not completely being 'the ideas and definitions that map abstract physics descriptions onto real things in the physical world' (Redish 2003).[10]

Some characteristic examples of early work on student misconceptions are Warren's identification of a difference between text-book authors' conceptualization of force and the Newtonian definition of force (Warren 1979), McDermott's collection of research on student conceptual difficulties understanding mechanics (McDermott 1984) and Hewson's case study on a set of one-on-one student-teacher engagements aiming towards helping students understand aspects of Einstein's special theory of relativity (Hewson 1982). The latter introduced the idea of beliefs which are not directly refutable by ordinary experience (such as time being absolute), claiming that such beliefs play a significant role in the origin of student difficulties. This prompted the idea that student misconceptions could actually be consistent to a point where they could be classified as naive theories.

2.1.2 Research on the consistency of student conceptions

McCloskey argued for such a view on student misconceptions, having found evidence that physics students develop resistant theories of motion (McCloskey 1983). These theories were found to provide both a description for *and* a causal explanation for moving systems remarkably similar to pre-Newtonian physics.

[10] Whenever I refer to student ideas different from orthodox ideas, I will refer to them as misconceptions. This choice is purely based on my usual jargon and should not be read as sympathetic towards specific research.

This view, that misconceptions are consistent to the point of being theories, was contested by Finegold and Gorsky (1991) who surveyed more than 500 students from both university and high (secondary) school, inviting 35 of these respondents to be interviewed, with the overall purpose of establishing evidence for consistent naive theories of aspects of Newtonian physics, but found none. They did find support for this lack of consistency in other significant studies and suggested that students in their reasoning are influenced by the objects and systems rather than by preformed laws and frameworks. For example, (Halloun and Hestenes 1985) tested more than 4000 college students for misconceptions, and found the answers consistent with 'common sense' views, rather than naive theories. In addition Reif (1987) argued that students, instead of relying on general definitions, invoked specialized knowledge in the form of 'memories' in attempts to give general descriptions.

2.1.3 The paradigm of constructivism

All of this student understanding (conceptions) research that I reviewed above could all be considered to be contributions to *constructivism*. This, rather than being a theory of learning, I would argue could be seen as an 'education researchers' paradigm' dealing with the essence of knowledge in which the central view is 'that learners construct knowledge on the basis of their previous knowledge and experience and that knowledge is an active process of construction' (Tammelin 2004, p. 14). Further, constructivist *learning* is based on students' active participation in critical reflection on learning strategies, and in construction of knowledge through multiple approaches involving both the students' prior knowledge and the knowledge that the teachers wish the students to acquire (Kanselaar 2002).

The emergence of the constructivist paradigm is given the status of 'Perhaps the most significant effect that research in physics education has had on physicists working in this area' (McDermott 1991, p. 304) page number. This leads McDermott and Redish (1999) in their comprehensive PER resource letter to conclude that research about *how* students think is needed (removing the focus on *what* students think). Thus creating an increasing *constructivist pedagogical* commitment. This focus on *how* is described in the next section.

2.2 Theoretically reflected works

2.2.1 Understanding *how* students think

Approaches to understanding how science students think were made as early as 1983 when Fensham, in an attempt to determine how to address student reasoning about concepts that differed from those of the professional practitioners', argued that the sociohistorical relation between curriculum and practice is only weak (Fensham 1983). Fensham argued that there is a sharp and uncontested divide between the conceptions and the reality of chemistry that inhibits the encouragement of pupils' interest in and understanding of chemistry. Most notably, Fensham argued that this leads students to not see a link between reality and instruction and therefore to reject the instruction. In 1968 Wagenschein had already proposed a solution to this problem by promoting exemplary teaching (cf. Wagenschein 1999 edition) that serves two purposes. The first is to present principles of the discipline using examples of application[11]. On the one hand this relieves the tedious and methodical repetition of these principles that take up so much of the curriculum; on the other hand presenting exemplars offers an opportunity to cover more material effectively in less time. The second purpose is to offer an engaging and autonomous method for the teachers to present their material in a way that in most cases (if chosen carefully) promises to break down the divide between content and reality described by Fensham.

In 1983 Driver and Erickson published a seminal paper on *how* science students think (Driver and Erickson 1983). Part of their empirical premise in this paper was that many students will have made sense of things from previous physical and linguistic experiences, which they now can fruitfully use to interpret some of the natural phenomena which they then encounter in science classes such as physics. These 'student frameworks' provide an understanding of the conceptual confusion that students typically experience when they find that their own 'theories-in-action' lead to different predictions and explanations from those frameworks sanctioned by taught science. Thus the notion of 'misconception' became better understood by the science education community as an 'alternative framework' and this

[11] Rather *exemplars*. Exemplars are examples that serve the purpose of illustrating the principles behind the example – such as engaging students in understanding the Coriolis effect by asking them to predict the impact-point of a stone falling from a large tower. If conditions are right, they may be surprised by the dislocation of the falling body, and later intrigued by being able to predict this dislocation by taking into account the revolution of the earth around its own axis. Letting a stone fall from a tall tower is an exemplar of the Coriolis effect.

then became a central theme in the educational perspective known as constructivism.

2.2.2 Revisiting constructivism

Smith, diSessa and Rochelle (1993) reacting to explicit assertions in misconception literature, proposed a constructivist perspective for how to view knowledge-formation on the cognitive level, in which three of the main points are that:

- prior knowledge, whether conceivable as 'misconceptions' or not, should be viewed as *the* primary resource for new knowledge,
- prior knowledge has always been productive (the principle of functionality), but might have been inappropriately extended, and
- all knowledge systems are resistant to change, and change will only be admitted if alternatives are proposed in a plausible manner.

Thus, talking about replacing or confronting faulty knowledge with correct knowledge is not useful and teaching by using this approach disregards this dogmatic stance.

The issue that is hinted at in the previous section is the issue of figuring out how students (consciously and even tacitly) think about learning. Cobern (1996) tells us that Conceptual Change Research stems from the constructivist notion. In Conceptual Change Research it is believed that learning involves a change of conceptions into more orthodox or superior conceptions, which, from a constructivist viewpoint implies that these appropriate conceptions must be *intelligible*, *plausible*, *and fruitful* to the learner – in order to be recognized by the learner as superior conceptions. From here research into epistemological influences in the teaching and learning of physics started to attract strong interest.

2.2.3 Research on epistemology

Epistemology can roughly be translated into 'accounting for knowledge', which means delving into the nature of knowledge and, in particular, how knowledge relates to such notions as truth, belief and reasoning. If a student does not believe that a bit of new, conflicting information is a valid knowledge element, the student will not bring that information into consideration – just as with the case of Fensham's chemistry students who dismiss chemistry and science on the grounds that they see no link to reality.

Research in student epistemology is an effort to figure out what it is that makes students understand concepts as intelligible, plausible and fruitful. It is also research into how we can change student epistemologies to fit the orthodox epistemologies – and hence encourage learning.

David Hammer (1994) has proposed and found evidence for a model that can be used for explaining the structure and content of student epistemology. This model is presented as a three-dimensional framework consisting of a set of beliefs about the nature of learning physics:

1. Beliefs about the structure of *physics knowledge*
2. Beliefs about the content of *physics knowledge*
3. Beliefs about *learning physics*
   (Hammer 1994, p. 151)

These beliefs must originate somewhere, and it was argued by Linder (1992) that the 'usual way' physics knowledge is presented, originates from 'scientific activity as an on-going collection of mind-independent facts about objective reality' (*ibid*, p. 111). Consequently, this often encourages even committed students to take a surface approach to learning and to associate the ability to solve stereotypical tutorial problems with understanding the subject matter. One implication of Linder's study is that students should be perceived primarily as individuals that make sense of and construct meaning out of what has been offered to them[12], and that this sense-making mechanism can be explained by understanding the epistemologies of physics students.

Effectively, the constructivist perspective posits that the process of learning forms and is perceived as an epistemological continuum; a continuum that is proposed by diSessa through the introduction of what he calls phenomenological primitives (p-prims) (diSessa 1993).

P-prims should be understood as the theoretical elementary particle of cognition. As such p-prims cannot be broken down to simpler elements, they 'constitute the basic encoding of the naive sense of mechanism' (diSessa 1993, p. 203) and each p-prim is valid for any situation fitting the p-prim. For example, consider diSessa's Ohm's p-prim: 'more effort implies more result' (*ibid* p. 126) that can govern a multitude of events everyday. Adopting the idea of p-prims and their implications for instruction becomes a question of identification and active engagement in understanding the applicability of the knowledge. In the educational context this

[12] As was already agreed upon in the Constructivist Paradigm – lending credibility to this approach to understanding learning.

could be helping the students to learn how, when and what to generalize (i.e. how to form orthodox physics conceptions).

2.2.4 Learning as a situated activity

Introducing a theoretically sound foundation is where PER has almost become an ideological commitment. These commitments stretch across a divide that has learning as an in-mind cognitive activity on the one hand and learning as a situated social process on the other. It is not easy to briefly further describe differences. Kanselaar (2002) has argued that the difference originates in Piaget's and Vygotsky's theories on the origin of the child's mental development:

> For Jean Piaget (1896-1980) the development of human intellect proceeds through adaptation and organization. Adaptation is a process [...] where [...] external events are assimilated into thoughts and [...] new and unusual mental structures are accommodated into the mental environment. [...] Piaget [...] considers that mental development organizes these schemes in more complex and integrated ways to produce the adult mind.
> [...]
> Vygotsky (1896-1934) [...] holds [...] that the process of knowing [...] [involves] the agency of other people and [is] mediated by community and culture. He sees collaborative action to be shaped in childhood when the convergence of speech and practical activity occurs and entails the instrumental use of social speech. Although in adulthood speech is internalized (it becomes thought), [...] it still preserves its intrinsic collaborative character.
> (Kanselaar 2002, p. 1)

What is meant here is that the difference between the two theories of knowledge construction is that Piaget depicted that the human mind as an autonomous identity that tries to make sense of the world around it through the construction of adequate cognitive structures. Vygotsky, on the other hand depicted the human mind to always be adapting to the surroundings (context). Since the contexts include other humans, this process becomes a rather complex process involving culture and ways of interacting.

An interesting alternative to the ideas of constructivism and one that embraces context as an integral aspect of learning is what has become known in phenomenographic[13] circles as a constituting of knowledge. This depiction of learning is based upon an 'anatomy of awareness' and 'intentionality' (Marton and Booth 1997), which has given rise to the 'variation theory

[13] 'Phenomenography is the empirical study of the differing ways in which people experience, perceive, apprehend, understand, conceptualise various phenomena in and aspects of the world around us' (Marton 1994, p 4424)

of learning'. (Bowden and Marton 1998, p. 7) describe this as follows: 'To discern an aspect is to differentiate among the various aspects and focus on the one most relevant to the situation. Without variation there is no discernment. We do not think in a conscious way about breathing until we get a virus or walk into a smoke-filled room. Learning in terms of changes in or widening in our ways of seeing the world can be understood in terms of discernment, simultaneity and variation. Thanks to the variation, we experience and discern critical aspects of the situations or phenomena we have to handle and, to the extent that these critical aspects are focused on simultaneously, a pattern emerges. Thanks to having experienced a varying past we become capable of handling a varying future.'

2.2.5 Situated cognition and the individual

In an article about the situated cognition model of learning the following description of learning being situated is given:

> [...] [T]he discourse of individual expression positions the learner as an expressive-creative individual, in such a way that learners learn, at the same time as they learn technique, to invest the product of their activity with their own expressive individuality.
>
> (Sinha 1999, p. 42)

And later in the article, citing Geertz on his description of the modern, western idea of individuality:

> [The idea of the self involves] a bounded, unique, more or less integrated motivational and cognitive universe, a dynamic center of awareness, emotion, judgment and action organized into a distinctive whole and set contrastively against other such wholes and against its social and natural background.
>
> (*Ibid*, p. 44)

This means that in understanding the learner, a teacher with a situated cognition epistemology will approach the learner as an individual learning in a community set in a specific context. In understanding any learning situation, it must be made possible to take into consideration more than just what happens in the mind; allowance must be made for an individual formed by, and habitually forming, their environment.

2.2.6 Environment as a discourse

Talking about individuals situating themselves or being situated in a culture or environment manifested as a *discourse* is another recent trend in PER, having ties to sociolinguistics and being strongly connected to situated cognition. Just as it is possible to be talking about learning as being

accepted or seeking admittance into a *community of practice* recognized by the sharing of symbolisms, beliefs, assumptions, values or just physical location (Wenger 2003), it is possible to talk about a social reality expressed through the Discourse of that reality – such as what we say, how we say it, in what circumstances and so forth (Gee 2005).

In this way it is possible to talk about the transition from being a physics student to becoming a physics practitioner as being admitted to the discourse of the physics community of practice. Promising results that go beyond the issue of teaching physics effectively have come out of framing research in this way. Current contributions to this area include, for instance, John Airey's (2006) work, influencing the public debate on the possible problem of teaching in English at Swedish institutions of higher education. Another example is Case and Marshall's study that open up new insights into the experience of learning by engineering students. The authors formulated a 'No problem Discourse model' rooted in the problem of self-actualization (Case and Marshall 2006) and often connected to the process of going through adolescence.

2.3 Theoretically reflected empirical work

2.3.1 Extended research on epistemology and transfer

Contributions following the trend suggested by Smith *et al.* (1993) and diSessa (1993) are for instance those of Hammer and his colleagues, see (Hammer *et al.* 2004) and Lising and Elby (Lising and Elby 2005), the later study being a case-study on the connection between epistemology and learning outcome for a North American physics student. The authors report finding evidence of a context-sensitive resource-based epistemology in that the participant of the study feels insecure in reconciling intuitive and formal thinking.

Hammer *et al.* (2004) on the other hand, take an approach that brought in generalizations from the array of misconceptions research in the field. They do this by drawing on a theoretically-founded epistemological framework that is similar to that of situated cognition. This lead them to conclude that the metaphor of knowledge transfer (that specialized knowledge can be generalized and transferred to other applicable general contexts) is not fruitful and should be considered a special case of their general idea of the use of knowledge: the context affects what knowledge is called upon.

2.3.2 Implementing the constructivist perspective

From the great focus that has been given to the advantages of taking a constructivist teaching and learning perspective, a number of suggestions for implementation have emerged. Some of these aim at helping students to increase their engagement. Crouch (Crouch 2004) found that students learn little from traditional classroom demonstrations, while just allowing a few minutes for students to predict the outcome of the demonstration, thereby engaging them, yields a better understanding. Meltzer and Manivannan (Meltzer and Manivannan 2002) recount the efforts of transforming the lecture-hall at three North American universities into an interactive engagement environment. Among many other initiatives they mention the introduction of flash-cards that lets students signal responses to the lecturer as the lecture progresses. The authors report significantly higher gains in student outcomes compared to the traditional lecture.

For further examples of many such initiatives that can enhance student engagement, see Redish 2003. Most notably, though, Redish (2003) gives a broad introduction to different surveys that, if given to students before and after teaching, can help educators assess the outcomes of any new initiatives. Results of such pre-post tests have been gathered in impressive numbers (6500 results) and show clearly that engaging the students interactively yields a better learning outcome than that of more traditional chalk-and-talk approach to teaching (Hake 1998).

Research into student conceptual difficulties is far from being a closed chapter. Even though most of the research that exposed learning hurdles has mainly been done in contexts of introductory physics, work is steadily moving into more advanced areas of physics learning, particularly quantum mechanics, for example, (Domert et al. 2005).

2.4 Situating PER

I started out by situating PER in physics, and will finish the chapter by revisiting this aspect of the research. Van Aalst (2000) for example, notes that the ontology of Physics Education Research, to a large extent, is in line with the broader field of Education Research and other humanity and social science fields. It cannot share the fundamental ontology of physics, which is well reflected in the various parts of this review chapter. On the other hand, it is hard to imagine PER researchers and practitioners not having a strong educational background in physics, since that would leave them without a sufficiently firm grasp of the subject matter (cf. McDermott 2001).

I thus would instead like to conclude this overview of PER as a field of both physics and education research by re-stating van Aalst's (2000) view that PER can be approached from the tradition of physics, and just as well be approached from the social sciences as long as it is approached with a solid foundation in both disciplines. In closing I would like to contribute to this argument: As a research community, we especially we need to mind the upkeep and maintenance of the social science and humanity aspects, remembering that the multi-disciplinarity dynamics of PER are *not* made up of only physics and PER cannot be treated only as a piece of physics science; but as a dynamic mixture of humanities and natural and social sciences.

3 Literature Situating this Thesis

In this chapter I will review the international contributions concerning issues related to student attrition. I will start by giving an 'Introduction' to my view on the purpose of the university. Then I will give a brief overview of research on the pattern of factors at stake influencing 'The initial choice of studying science' at a tertiary level. In the third section I will review literature that can inform us of the effects of the pattern of factors at stake – the effects of the so-called 'STEM Pipeline'. Then I will summarize literature that has contributed to insight into 'The causes of attrition'. Finally, a concluding section discusses what attrition expresses and consequently leads to 'Perspectives on attrition' situating this thesis in the research field.

3.1 Introduction: my view on the purpose of the university

Some five years ago I took an undergraduate course in the Didactics of the Natural Sciences. Here, we were presented with a collection of prize-winning essays themed 'Natural Science, Education and Competence' of which all the winning contributions had a perspective that gave Higher Education a role that should be thought of as deeply intertwined with the surrounding society (Hansen *et al.* 2000).

One essay written by Rie Popp Troelsen (2000) especially impressed and inspired me. In this article, Troelsen departed from a dualistic general idea of chemistry education as an institution that has internal obligations. Instead, she argued that the university must continue a tradition of a high degree of disciplinary quality while on the other hand also meet the demands from the surrounding society. These societal demands Troelsen saw as a general requirement for competent graduates. She listed the required competencies as: The competence of Learning and Knowledge; the competence of Cooperation; the competence of Personal Innovation; and the competence of Identity Creation.

What struck me so profoundly was that in order to understand this essay I would have to depart from my personal beliefs about science – the mantra

that science exists for the sake of science. I believed that there was something uniquely beautiful and uncomplicated about science in the sense that, since the days of Enlightenment, it finally had been removed from the political and religious whim of the surrounding world. Unfortunately Troelsen showed me that from the perspective of the individual, the society in its entirety is effectively an educational institution, in which the University is to be perceived as merely one of many parts. Science does not exist for the sake of science, but for the sake of society. Pragmatic as this view might be, it has become the underlining theme for my thinking about Physics Education Research. It is also the underlying perspective that I wished to explore with this thesis about student attrition vis-à-vis physics* at Uppsala University.

3.2 The initial choice to study science.

The questions of performance and motivation must be closely connected to the question of attrition. In the following I will review a number of publications concerning motivational aspects that lead students to choose science. Most of these works are concerned with gender differences. This must not be understood as a general perspective that I have about gender issues; but rather as an approach to understanding cultural variances in students, as these variances are often most evident in research that separates gender. The perspective that the university is an intimate part of the surrounding society is expressed by a number of researchers explaining how and why gender differences in secondary science education participation appear.

3.2.1 The importance of appealing to pupils' everyday life

Reid and Skryabina (2003) were concerned by what they saw as a dramatic change in Scottish pupils' interest in physics as these students progress through their secondary schooling. In Scotland physics appears to be a very popular subject in primary school – actually the fourth most popular subject after English, mathematics and biology – indicating that the overall position of science is very strong. The authors find that the interest for continuing to study physics in a primary and secondary school context is very high during the early years of school. However, during the last years of secondary education, the physics teaching tends to take on the form of being more abstract and rule-dominated, in other words a traditional approach. At this time, pupils' interest, predominantly girls', subsides. At the end of secondary school's fourth year 92% of the female students and 89% of the male students expressed an intention of wanting to continue taking

physics courses during the next one or two years of secondary education. At the end of these years only 13% of the girls and 11% of the boys intended to continue with university physics studies.

The authors conclude that interest in a subject is to a large extent related to the subject's relevance to the student's lifestyle: Only as long as physics is taught in a way that appeals directly to the pupils' everyday life, or in an application-led fashion, can interest be ensured to an incredibly high degree.

That interest in the natural sciences is related to societal factors is also expressed by American studies. In a recent American publication, Cho (2006) finds that women's college attendance relative to that of men has been rising over the past three decades. The author found this increase connected to women's high-school performance in mathematics and science courses; an increase explained by the high-schools' increasing ability to prepare women for further education and an increase in women's drive for achievement as a response to increased labour market opportunities.

3.2.2 Extrinsic versus intrinsic motivation

Cho's American study is confirmed by Langen *et al.*'s (2006) research on students' choice of science and mathematics in senior general secondary education in the Netherlands. Langen *et al.* (2006) find girls' choice to be correlated with what the authors call extrinsic values (i.e. the estimated utility of study and career choice), as opposed to boys' choices being correlated with intrinsic motivations such as interest and enjoyment in the subject. This difference leads the authors to convey a concern, rooted in previous research, that a proportional dislocation of interest *away* from science related subjects leads to the same proportional social inequality: If girls do not choose science related subjects during secondary education, their later educational possibilities will be limited accordingly. However, Walker *et al.* (2006) found that extrinsic motivation (for instance feeling motivated by labour market opportunities), predicts a shallow 'surface' (Säljö 1982) approach to learning.

I take this to mean that if girls have a tendency to find motivation in extrinsic factors, such as both Cho (2006) and Langen *et al.* (2006) found, and if extrinsic motivation leads to low-outcome learning strategies (Walker *et al.* 2006), bad self-esteem might be justified as a result of this vicious spiral.

Actually Langen *et al.* (2006) quote a number of curious dichotomies in motivational aspects divided between genders: For instance, findings that

boys ascribe success in a subject to talent, while girls ascribe success to coincidence or luck. At the same time, boys ascribe failure to bad luck or lack of effort, while girls ascribe it to lack of capacity. Such judgments as to individual capability to perform academic tasks are in literature often referred to as *self-efficacy* beliefs (see for instance Gerhardt and Brown (2006) for a condensed introduction to the term and uses). In many areas, including science and mathematics, it has been shown that self-efficacy is correlated with accomplishment (Britner and Pajares 2001) and vice versa (Zeldin et al. 2007).

Does this in effect mean that girls are worse at science and mathematics then boys? According to the latest results on the standardized OECD PISA scientific and mathematical literacy tests, males outperform females in mathematics, but in science, the cross-national picture becomes scattered[14] (OECD 2004). Furthermore, standardized tests like the American Scholastic Aptitude Test (SAT) have shown a systematic gender bias in predicting women's later educational achievements (Young 1991).

To take this further: science appears less motivating as it approaches the 'axiomatic' form that is typical of much university science education. For some groups science is also a source of bad self-esteem, but for certain types, who can disregard a lack of intrinsic interest and instead focus on the professional advantages, science appears attractive. A concern is that such a focus does not lead to a desirable outcome. As such, choosing science becomes rational rather than passionate.

3.3 Differences in tertiary education: the STEM pipeline.

The question now becomes whether early performance- and motivation-patterns follow through to tertiary education.

An example of a study approaching that question is Langen and Dekkers' (2005) cross-national comparison of the proportions of female students that apply for university programmes in science, technology, engineering and mathematics (STEM) with a meta-analysis of international societal factors that have been described as influential on youths' educational choice. The authors found four categories of social context characteristics:

[14] Males clearly outperform women in Denmark and Austria, while in countries such as Spain, the UK, France, the Netherlands and Sweden almost equal performance is seen. In roughly 12 of the participating 28 countries women perform better than men.

1. The degree of freedom of choice in required courses during secondary education that are supposed to be university-preparatory (such as mathematics and physics at a certain level): 'by expanding the number of subjects that must be chosen, it is less likely that students will restrict themselves to subjects traditionally suited to their gender.' (Brown 2001 p. 183).
2. The job market and economy: Based on studies showing that students of science-related subjects are far more influenced by political economical considerations than students of other subjects, and that females are generally less occupied with concerns of this sort, the conclusion is that people who do not let economical concerns play a factor in their choice of study, do not tend to choose science. [15]
3. Social views and traditions dictating that science related subjects are 'boring, masculine and remote from everyday life' (*ibid*, p. 335).
4. Government policies in funding educational reforms, promoting interest in science related subjects and creating equal possibilities for education across social layers.

For this fourth category, the authors particularly analyse factors contributing to women's possibilities of participating in science careers described by the dictum that science careers are inflexible in the way that half-time jobs are rare and that it is difficult to take a few years off. To this end, aspects of childcare, parental leave, family structures and study support are compared between four countries: the USA, the UK, the Netherlands and Sweden.

In comparing childcare and leave provisions Langen and Dekkers (2005) find a partial explanation for women's high general participation in the job market, but if we take a closer look at physics, the situation seems to be unconnected:

In Nordic countries female physics university researchers are, to say the least, scarce (Hasse 2002a). Females in physics, both students (Danielsson 2007) and researchers (Hasse 2005), feel that they have to conform to some masculine norm even though the Nordic countries are considered paragons of gender issues (such as indicated by Langen and Dekkers 2005). In Italy, on the other hand, the lower number of female scientists is not felt by the women to be caused by a view of women as less capable scien-

[15] At first glance, this category might appear to be a contradiction to previously reviewed literature. But this might not be the case. If we take the statements literally it can mean that there are fewer women in STEM because the ones that have made this choice are only the few that *are* concerned with labour market opportunities (of course in general terms at the level that shows in statistics).

tists (or even different scientists), but simply because it is hard to hold a top position for women in a country where becoming a mother is a problem (Hasse 2005).

An explanation for why gender issues seem to be expressed differently within physics in Scandinavia compared to Italy might be found by focusing on the so called STEM-pipeline:
A general theme of the literature presented in this part of the review, has been the assumption of the existence of a 'STEM pipeline': that students who have chosen and been accepted into university STEM education, have previously predominantly been occupied with mathematics and science education – either because of regulation, or because of interest.. This is not necessarily so. In Italy it is possible to study university physics with a background in the humanities, and this option is extensively utilized – especially by the female proportion who comprise almost half of the new physics students (Hasse 2005). Hasse (2005) recounts how students with a humanistic background are deeply valued by educators and almost envied for their abilities to reason and think in abstractions. Hence, what is called a pipeline in many other countries rather appears to be a *funnel* in the case of Italy. This funnel seems to inhibit a thinking of science and humanities as two extremes of an academic spectrum, each with their gendered characteristics. Instead, choosing a secondary education in either the humanities or in the natural sciences will give the student different competencies, but all are thought of as valuable contributions to further physics education and practice.

3.3.1 Retention and financial support

Returning to Langen and Dekkers' (2005) article, another curious result is the comparison that concludes that retention is negatively related to the extent of governmental study-support offered: In this comparison Sweden is the country that offers the cheapest education (i.e. no tuition; grants and loans for all students), but also yields the lowest rate of retention (48%) for all tertiary programmes, compared with England, the Netherlands and USA (83%, 69%, 66% respectively).

If we take a brief look at retention rates in Denmark and Norway, the two countries that have student-support policies that most closely resemble Sweden's[16], retention rates are astoundingly similar: The Danish national retention rate for science at bachelor level is 45% (Johannesen and Kromand 2003), and the Norwegian overall retention rate is 44% (Hovd-

[16] Other countries such as Finland could possibly be added to this list, but my limited experience with the Finish culture makes me hesitate.

haugen and Aamodt 2005) [17]. Further, Hovdhaugen and Aamodt (2005) state that research on attrition in Norway from the past two decades all points towards aspects of social context characteristics being important issues.

To take this further: as social security for students increases, attrition rises. Also, but not necessarily connected, the gendering becomes more problematic. From the Italian study reviewed, it appears that the STEM-pipeline could be the root of an unnecessarily narrow form of recruitment. This may allow issues of efficacy to be carried through the whole of the individual students' experience with education.

3.4 The causes for attrition.

In this section I will review some of the more direct approaches to studying attrition.

3.4.1 The negative and positive aspects of attrition

An Australian report stated that research so far have been unable to attain a clear and comprehensible picture of student attrition from institutions of higher education (McInnis *et al.* 2000). Instead, the authors of this report make an extensive literature review of existing research into student attrition. Referring to an evaluation published by DEETYA[18], McInnis *et al.* (2000) list positive and negative aspects of student attrition:

- Positive aspects of attrition are that highly prestigious institutions regard attrition as a form of quality control, and what appears as a premature withdrawal from education can also be perceived as a case of acquiring a limited array of particular skills necessary for employment.
- Negative issues of attrition mentioned are, on the one side, economical considerations such as the institutional waste of resources, the reputation of institutions with high attrition rates, and the societal concern for wasting talents. On the personal side, withdrawal is almost always connected with a lowered self-esteem as a result of academic failure.

[17] This number is based on a study following 2000 students from 3 different universities, of which one was a technical university. These students were followed from when they enrolled in 1999, until the report was finished in 2005.

[18] Department of Employment, Education, Training and Youth Affairs: A department of the Australian government.

3.4.2 Student differences

Yet regarding attrition as a form of quality control is wrong, argues Felder and Brent (2005). Instead, learners should be understood as a diverse group striving towards the same goal – namely graduating. This diverse group employs very different strategies –some of which are compatible with the teaching styles of the institution. However, many are not.

Felder and Brent (2005) list three aspects of this diversity in students' strategies:

- Different ways of attaining and processing information – such as attaining knowledge as theories and abstractions or on the other hand approaching knowledge as facts and observable phenomena, processing that information either through interaction or introspection.
- Different approaches to learning – for instance believing that learning is reproduction by rote memorization and formula manipulation or believing that learning is understanding and finding meaning.
- Different intellectual development levels – in the one extreme believing that scientific knowledge is certain and objective and at the other extreme believing that scientific knowledge is contextually and relatively dependent on application and observer.
- Most strategies, whatever they are, can be ascribed to students' attempts to meet what they understand as the educators' purpose – or pragmatic adjustments aimed toward graduation.

3.4.3 The importance of culture and social interaction

Hasse (2002b) performed an anthropologic field-study among Danish first-year physics students, and concluded that large parts of the process of becoming a successful physics student consisted of reading subtle cultural indicators and adapting to them. She also noticed that the students who had experienced difficulties in, for instance, being welcomed as valuable members of groups doing compulsory group work such as laboratory exercises and writing reports, were not necessarily the 'less talented', but rather the ones that did not embrace or understand what behaviour was 'correct'. As an example she observed the gradual social exclusion of a person from groups because she *was* 'weird': She wore short skirts and giggled during lectures. 'And she was weird. But I don't know if she would have been weird in the context of an anthropology lecture. There people are generally weird, and short skirts and giggles are almost mundane.' (Cathrine Hasse, personal communication)

Another sort of exclusion found by Hasse (2002b) occurred when certain kinds of students did not understand the laboratory practice. One example is the annoyance felt by girls in the laboratory when the boys left the prescribed experiment in order to explore or play with the equipment. This was followed by a feeling of unfairness and incomprehension when praise and positive attention was given to these boys by the instructors.

A different example is a woman at a computer-terminal halting her active participation in the work, and giving control over to her male co-worker. You can say that her resignation is a kind of self-censorship: she does not act on her own feelings about the right conduct in relation to the task at hand, but lets the surroundings and people's reactions define what is right. By resigning, she becomes a passive component of the computer-lab; a girl on the chair next to the guy who is doing the programming. She was a victim of one expression of what Bourdieu called *symbolic violence* (Bourdieu 1990). Symbolic violence is an invisible element of social interaction that forces common non-negotiable norms on individuals through censorship, self-censorship, behavioural changes and even exclusions (Hasse 2002b).

By gathering different aspects of reactions to the 'correct' behaviour characteristic for the first-year physics students and the people they associated with (such as the examples above), Hasse was able to demonstrate the complexity of the social interaction that students had to adapt to in order to succeed. She gathered knowledge about this 'correct' behaviour into one term: *Sprezzatura*:

> Sprezzatura covers abilities, [...], a sense of elegant formulations and the correct behaviour. As well as with symbolic violence, sprezzatura is connected to the already established groups and the groups' generalized mentality as it is expressed when individual and group interact. Sprezzatura can be a characterisation of the individual's conduct-knowledge which is the incorporated knowledge about how to act, that turns into an automated reaction to the correct cultural codes inherent to a certain world. This incorporated knowledge can turn into conduct-ability – the correct physical movements, forms of appearances and presences. Worlds are different and so are sprezzaturae. The sprezzatura of one world can be subject to symbolic violence in another. Sprezzatura is the conduct-knowledge that renders symbolic violence superfluous, while lack of sprezzatura is what gives rise to symbolic violence.
>
> (Hasse 2002b, p. 149 – my translation from Danish)

Sprezzatura was found in a wide variety of forms, for example, knowing when plagiarism is constructive group work, how forms of being 'a bad physicist' can still be compatible with the aspiration to become a re-

searcher, liking science fiction and playing games, and even how to be interested in questions of religion with respect to physics.

Put like this, sprezzatura is very similar to mastering the 'shared repertoire' of Wenger's (2003) Communities of Practice theory – but with a poetic ring. The shared repertoire is described as including 'the discourse by which members create meaningful statements about the world, as well as the styles by which they express their forms of membership and their identities as members' (Wenger 2003, p. 83). Yet Wenger insists that being a member of a community is a negotiation of meaning because the shared repertoire 'reflects a history of mutual engagement and remains inherently ambiguous' (*ibid*, italics added) and continues: 'ambiguity is not an absence or a lack of meaning. Rather, it is a condition of negotiability and this is a condition for the very possibility of meaning.'

From this point of view, it is no wonder that the non-negotiable norms of social conduct ultimately enforced by symbolic violence – the social reaction to an individual's lack of sprezzatura – is such a powerful social mechanism. Individuals who find themselves or are found to be lacking sprezzatura are in their actions rendered meaningless relative to the surroundings. Furthermore, a negotiation of meaning is not possible until you are a legitimate member of the community. Thus non-conformity will lead to exclusion or self-exclusion –because of course, the mechanism works both ways: The women in the lab saw the men's play as meaningless, while expressions of their consequent irritation are perceived to be erratic by the men.

3.4.4 The *weed-out* tradition

In the United States it was found that the practice of some institutions was met with incomprehension by certain types of students. Seymour and Hewitt (1997) conducted an extensive series of interviews with more than 450 students from 13 different science, mathematics and engineering institutions. They found that students' concerns about their studies to a large extent were equally shared among students who did not plan to leave their studies and those who switched to majors outside science. Seymour and Hewitt concluded that the differences between the students were to be found in their coping abilities. A major issue the students had to cope with was the implicit *weed-out* tradition of North American Universities. This tradition can be expressed very directly when the lecturer for instance introduces the first lecture with a: 'Take a look around you. The persons to your right and left are very likely not to pass this course.' The lecturer bluntly points out this fact derived from experience teaching the course, most likely intended to spur the engagement of the students.

Another, but less obvious, face of the weed-out tradition is to grade students relative to each other – the so called curve grading – that leads students to compete[19].

Seymour and Hewitt (1997) argue that this weed-out mechanism targets a traditional white male persona, intending to discourage those students who do not have what it takes to become professionals. However, the typical breadth of students can no longer be characterized by a narrowly defined classical masculinity, because students are both male and female, they are recruited from all social layers and are of many ethnicities and political persuasions. Put differently, Seymour and Hewitt say that what motivated a typical upper-class white male in the 19th century is no longer what motivates young people of the new millennium. On the contrary, some students feel discouraged; *not* because they are unskilled or unable, but because they cannot read the subtle hints of the intention of the weed-out culture. This means that students who leave are not necessarily limited to those students who could not have become skilled scientists or engineers.

Sheila Tobias (1990) calls this group of students 'the second tier': a large group of able and intelligent students who do not study science because they reject the culture of science.

To take this further: A top-down approach, such as viewing students as a homogeneous mass that has to conform to a pre-defined educational institution and set of thought, is not desirable if attrition is to be limited. This is true especially if this set of thought is archaic and out of touch with reality – which is what Seymour and Hewitt argued. It simply does not leave room for the array of individualities that are the reality of the present-day talent-resource: the connection between 'talent' and 'success' in physics is to a large extent a matter of 'talent' as popular conduct, rather than disciplinary ability.

3.5 Perspectives on attrition

As promised in Chapter 1 we need to explore why an attrition rate from physics* of approximately 50% should be considered a problem. I will give reasons based on previous research. First of all as may be seen from the

[19] If a large group of students are prone to perform purely on an examination, it means that the chances of getting good grades are higher for the students who perform slightly better. Thus curve-grading encourages competitive rather than cooperative behaviour.

data presented in Chapter 1, the physics* rate is at times actually slightly better than Scandinavian averages. Secondly, most of the students who leave studying physics*, do not 'drop out' completely, but change their education direction.

If we for instance examine the numbers for attrition from the University of Copenhagen: 80-90% of the students who start studying at the faculty of natural sciences in Copenhagen, take out a degree in higher education of some sort (Johannesen and Kromand 2003). However, the number isolated for and contained within mathematics, physics and chemistry reveals an attrition rate of 60% (*ibid*).

3.5.1 The centralized and decentralized view of attrition

The extensively quoted theoretical model of student attrition developed by Vincent Tinto (1975) argues for the necessity of distinguishing between students that leave higher education entirely, and students who just transfer to other educational programmes within institutions of higher education. If not, it leads 'state planners to overestimate substantially the extent of dropout from higher education' (ibid p. 90). In my view this statement hints at Tinto not taking into account institutional and student differences when estimating the extent of the problem of attrition. I will refer to this as a *centralized view* that is exclusively concerned with 'dropout' (attrition) from an entire institution (i.e. not just physics). This means that 'dropout', such as Tinto's (1975) model seeks to explain, will inevitably lead to a notion of attrition between systems inside the institution (i.e. between programmes) as a form of transition.

Opposed to this centralized view, is what I call the *decentralized view* that perceives all attrition as a loss even if attrition is actually transition or a regular attrition from university education.

That Tinto (1975) takes a homogenous view of students has been one of the principal points of criticism of his work. For example Bean and Metzner (1985) specifically argue that a non-traditional student is not covered by Tinto's model. I would think it natural to extend that criticism to also include the need for taking into account differences between institutions within the university.

However, Tinto (1975) concludes his work with a call to give further attention to explaining why ethnic background is a predictor of dropout. He also forms a general conclusion that voluntary withdrawal (i.e. the student chooses to leave, rather than literally being forced by the institution to leave) is linked to the individual student rejecting the culture of the insti-

tution in a way that makes the student appear to be a 'social isolate' or 'deviant' relative to the other students (*ibid*, p. 117). This makes Seymour and Hewitt's (1997) idea of an archaic misdirected weed-out mechanism an attractive model for explaining student attrition from physics: A model that to a much larger extent captures the subtle facets of attrition.

Now, there are several reasons that attrition from individual institutions such as physics* should receive special consideration: The primary being that attrition is a useful indicator in evaluating the programme – a consequence of my view of the role of the institution introduced in the Introduction in this chapter. Crisply expressed by OECD: 'high drop-out rates indicate that the education system is not meeting the needs of its clients.' (OECD 2003, p. 8). Such a conclusion can be reached by reading findings that again and again show that the students who leave systems within institutions, are most often *at least* just as able students as the ones who remain (see for instance Humphreys and Freeland 1992, Seymour 2001 and Seymour and Hewitt 1997).

3.5.2 Educational consumerism

Another issue, perhaps more pressing, is that students in Scandinavia might appear to be acting as educational consumers. A hint at such a model is illustrated by a Norwegian study of general attrition and a Danish study of students' progress in the natural science programmes at the University of Copenhagen.

Hovdhaugen and Aamodt (2005) approached the problem of Norwegian student attrition from two different angles:

One approach was an analysis of certain factors' (such as age, ethnicity, grades, parents' levels of education, goal and choice of study) correlation with retention and attrition. Another approach was to use questionnaires that probed students' own reasons for leaving the choice of education and institution.

The factor-analysis found a connection between students' choosing to leave the first choice of studies and the different places of choice, while students' own reasons for changing given in the questionnaires did not include contextual concerns of that sort. The authors interpret this result as merely an *apparent* contradiction that actually covers the emergence of evidence for a 'study market'.

The Danish study (Wang *et al.* 2003) scrutinized the progress of natural science students essentially the same way as Hovdhaugen and Aamodt's

(2005) *one* component focused on 'factual' factors. With this approach Wang *et al.* concluded their investigation by finding correlations between student progress and factors external to the university education – such as grades in gymnasium, the level of previous education, gender, sabbatical years, and interest in the studies[20]. This study did not thoroughly interpret students' own reasons for leaving. Had they done so, they might very well have found the same contradiction as found in the Norwegian study.

Hovdhaugen and Aamodt (2005) argue that the 'study market' has emerged as the competition for students between institutions has increased. This fits very well with Langen and Dekkers' (2005) proposition that cross-national differences in attrition can be seen as an expression of an economical emancipation of Swedish students: An emancipation that allows students to make choices based on apparent interest, rather than on financial considerations. As previously mentioned, students' economical situations in Sweden, Denmark and Norway are to a large extent comparable, and from this point of view, so are the patterns of attrition. This means that viewing student attrition as a pattern emerging from students acting as consumers might help us understand the way students interpret their own choices of leaving or changing.

3.5.3 Setting the frame for this study

The literature I have reviewed so far can be summarized in a form that resembles a working hypothesis, or framework, for interpretation:

Students who leave do so because of a rejection of, or exclusion from, the culture inherent to the institution of education. This rejection is related to the students' background, since certain 'types' are more prone to rejecting or feeling rejected. Most Scandinavian students might not perceive the rejection as an actual rejection, but rather as a choice (*choosing* another education, rather than *rejecting* the initial one), as a consequence of the personal and economical freedom they experience.

By continuing the trend of contemporary research into student attrition from higher education, my work becomes a contribution aimed at giving insight into student attrition from a decentralized view. Gaining such insight could help the physics institution at Uppsala University become more attractive to students in a society where education might have be-

[20] I must confess that I have a hard time explaining how interest in the studies is external to the institution, but from the text that I refer to there is no doubt, that the authors of this investigation are of that opinion. As a causal explanation, other more exciting programmes are often mentioned – and these are, in fact, external.

come a 'buyers' market as a result of the socio-economic security characteristic to Scandinavian countries. I will abnegate further considerations as to the politico-educational ramifications of teaching consumers rather than students. Instead, the assertion that part of teaching physics is a question of *also* making sure that students want to become part of the culture at the institution becomes the conceptual umbrella framing my study. My purpose is to shed light on critical elements of the physics student culture that lead some individuals to leave their initial choice of studies. My purpose is also to lend strength to the argument that an aspect of the student culture is to perceive 'students as consumer' – a perception that I see contributing to attrition, and interesting on a much broader scale, than simply within the structure of physics education at Uppsala University.

In this chapter I have given an overview of research related to student attrition, with the specific aim of informing my own study of student attrition from physics*.

I have argued theoretically and by using the notion of the immediate utility of the value of perceiving all attrition as a loss that is worth attention. The following parts of this thesis will focus on uncovering some of the themes leading to students choosing to leave physics*. These themes are thought to contribute to a more general understanding of the culture in physics* and also the general educational culture presently emerging out of a society of great social security.

4 Methodology

In this chapter I will account for the methods I have used in this thesis for acquiring and processing data. The sections on methodology are intended to give the reader insights into the sources of some of the assumptions and presuppositions that underpin my work. Specifically, the notion of learning as a social and central aspect of all experience.

I would like the reader to keep in mind that I have only selected those aspects of methodology that have a direct bearing on my interpretations of the empirical data. I would encourage those interested to pursue the references – especially the works of Wenger (2003) and Gee (2005) to whom I am particularly indebted.

Besides the inquiry into attrition presented in Chapter 1, my other main source of information into the highly complex problem of student attrition, came from former physics* students who had left physics*. Seven individuals, all of whom had started physics* between 1999 and 2004, agreed to participate in my study; and they shared their university experiences with me in a series of individual interviews.[21]

In order to select the students and to further contextualize their experiences, I was able to access their student records from the University.

4.1 Methodological perspectives

4.1.1 Choosing a perspective

Choosing a framework in which to situate inquiries into aspects of learning is, as stated in my literature review in Chapter 3, a question of choosing a paradigm.

Anna Sfard (1998) shows how the two meta-frameworks for learning, the cognitive and the situated cognitive / sociocultural perspective, can be

[21] For a brief description of the selection process, see Appendix 1.

boiled down to two metaphors for learning: The Acquisition Metaphor and The Participation Metaphor respectively. What is interesting about this approach to dealing with the friction between the two predominant perspectives of learning, is that Sfard makes it apparent that the two metaphors are not expressions of two incompatible ontologies, but rather incommensurable (not mutually exclusive) reductions of a highly complex issue (i.e. learning) fit for different purposes:

> If, for example, one's purpose is to build a computer program that would simulate human behavior, then the acquisition metaphor is likely to be chosen as one that brings forward the issue of representations – something that has to be constructed and quite literally put into a computer. If, on the other hand, one is concerned with educational issues – such as the mechanisms that enable successful learning or make its failure persistent, then the participational approach may be more helpful as one that defies the traditional distinction between cognition and affect, brings social factors to the fore, and thus deals with an incomparably wider range of possibly relevant aspects.
> (Sfard 1998, p. 11)

In this sense, not only does the choice of perspective speak to my personal convictions regarding the nature of learning, but it is also a given in accordance with my research question. This perspective is as indicated, the situated cognitive perspective, which will be described in the next section.

4.1.1.1 Situated learning and Communities of Practice

The main pillar of situated cognition is the realization that 'isolated knowledge elements', such as the idea of knowledge in the form of decontextualized abstract representations, is a meaningless notion and does not constitute knowledge[22]. Instead, knowledge elements have or gain meaning if they are, or can be set in relation to other knowledge-elements and made specific to a situation (Lave and Wenger 1991).

For example, writing $E=mc^2$ is not in itself a knowledgeable act, it is an abstract decontextualized representation of knowledge[23]. To make the use of $E=mc^2$ meaningful requires knowing that E is energy, m mass and c the speed of light. It also requires knowing in what situations this statement is significant and in what situations it is not. To know in what situations it is significant requires knowing the ramifications of an 'equals sign', it re-

[22] Instead they represent exactly what they are: decontextualized abstract representations, that if applied in a knowledgeable way (e.g. knowing from what contexts the representations were derived and what context can be recognized as a similar applicable context), will tell or predict something about a given context.

[23] See for instance Bodanis (2000), a 350 pages biography of this equation separately tackling its components (E, =, m, c, and 'squared') and in doing so involving more than 200 years of physics.

quires knowing that energy is not something one would 'ordinarily' relate to mass and so forth. In short, knowing $E=mc^2$ requires the ability to relate the representation to a context – to situate the representation. Notice, however, that I do not claim that writing $E=mc^2$ is a meaningless act in itself, but rather that for the isolated act of writing $E=mc^2$ to be a knowledgeable act, a great many elements of the situated knowledge encoded in the act of writing are required. Einstein's famous equation can be assumed shared among the individuals to who's benefit or satisfaction it is written.

This means, that learning to act knowledgeably is not only a question of internalizing representations of the knowledge in question, but also to gain insight into the community in which such elements are of value and have meaning – as would be necessary if I were to define what the word 'ordinarily' used earlier, entails. In this way 'learning is a process that takes place in a participation framework, not in an individual mind' (Lave and Wenger 1991, p. 15).

At this point, it might be beneficial to define learning as I have come to understand it and will use it in my study.

Learning is a gaining of knowledge, and learning is what you do or conceptualize in order to be able to act knowledgeably. Acting knowledgeably is making sense – in most cases making sense to others, but in special cases it is sufficient to make sense to oneself. Although not every act derived from the process of learning is recognized as knowledgeable, there will always be elements of rationalization involved – such as acting according to experience or expectations.

Loosely interpreted, Plato defined knowledge as 'justified true understanding' (Audi 2003, p. 220), and in this sense, acquiring knowledge – or learning – could be 'justifying true understanding'. What 'justification' and 'truth' entails is a central definition or question inherent to each discipline, community and individual.

Such disciplines, communities and individuals have to a great extent found it useful to decontextualize knowledge for the purpose of reproductability and applicability, creating laws and theories. Such laws and theories needs to be decoded when applied to specific purposes, and the key to the decoding lies in the practice of these disciplines, communities and individuals.

It is clear that in praxis learning cannot be recognized as such without the involvement of a community – a group of people with a shared set of values regarding what constitutes learning and justification of knowledge: a shared practice. The shared practices of the physics community have been

described (and problematized) by Kuhn (1996) as a 'disciplinary matrix', of which the shared components include the symbolism of equations, values and exemplars.

Lave and Wenger (1991) have described the progression of learning, in the case where the reason for learning is to acquire membership of a community of practice (e.g. becoming a physicist), as initially involving 'legitimate peripheral participation'.

If a person is a member of a community of practice, the person will also share the values of that community or system of relations. 'Learning thus implies becoming a different person with respect to the possibilities enabled by these systems of relations' (Lave and Wenger 1991, p. 53). Becoming a different person is constructing a different identity – a process. So in order for a person to become a member of a community, the person will have to be allowed to participate in the practices of the community – but until values are shared and until the process of identity formation is recognized as complete, this participation will be peripheral. In the case of schooling, among others, this peripheral participation is legitimate. In other words, even though a student is not a capable physicist, participation in physicist activities is often encouraged, and education is often designed in a way that encourages students to mimic 'modes of disciplinary discourse' (Airey and Linder 2006). Thus, being a member of a community of legitimate peripheral participators, such as a student body, can in itself be considered a community of practice.

If learning is an aspect of identity formation in terms of learning to share the values of a group (the shared repertoire), then it is also a process of inclusion into a culture. If a person is not included in this culture, for example because he or she leaves, then this exclusion is an expression of incommensurable cultures – incommensurability between this culture and the culture of the person. This is my main premise for my data-engagement: That attrition is a result of an incommensurability of cultures / discourses.

Mimicking practice, or legitimate peripheral participation, has often been compared to learning a language, by including in the language the idea of a shared repertoire (routines, words, tools, ways of doing things, stories, gestures, symbols, genres, actions, or concepts inherent and defining for the community in question) (Wenger 2003, p. 83). Thus, learning to become 'discursively fluent' (Airey 2006) might be an appropriate metaphor.

Gee (2005) has developed a discourse analysis methodology, the 'big D' Discourse analysis, that is especially suitable for understanding aspects of legitimate peripheral participation.

4.1.1.2 Discourse Analysis

There are two reasons why I have chosen to embed my methodology in 'big D' Discourse analysis (cf. Gee 2005). Firstly, to provide a coherent analytical framework within which I can analyse the discursive transactions captured in the interview transcripts (which, as described below, form one of my main sources of data). Secondly, because Discourse analysis is deeply embedded in the situated cognitive perspective which I adhere to in my analysis. The main difference between conventional discourse analyses methodologies and Discourse analysis, is that discourse analysis often is a focus on what is said, the words used, often informed by linguistics, while Discourse analysis also includes all those other aspects of communication that does not solely relate to the language-in-use (Gee 2005). As Gee puts it:

> All life for all of us is just a patchwork of thoughts, words, objects, events, actions, and interactions in Discourses.
> (Gee 2005, p. 7)

In other words, Discourse is everything that we perceive (while what we do not perceive, is nothing). In this way Discourse analysis has a strong phenomenological foundation. When one undertakes Discourse analysis, one is careful to pay close attention to not only what is said, the actual words (micro level), but also to the identities, the people and the situations (macro level) that lead to these words being spoken:

> Discourse models are an important tool of inquiry because they mediate between the "micro" (small) level of interaction and the "macro" (large) level of institutions.
> (Gee 2005, p. 71)

An example of a Discourse analysis that leads to the proposition of a Discourse model is Case and Marshall's 'no-problem' Discourse model (Case and Marshall 2006). When interviewing South-African engineering students about their learning experiences, they noticed that students often portrayed their experiences of a course in a way that conflicted with the actual results of assessment (Case 2007). For example, students may claim that they are doing well in a course, only to fail. Failure was explained away as not necessarily having something to do with ability; but rather a happenstance of circumstances, such as a particularly obstinate integral (so to speak), or a question of not having studied enough for that particular test.

However, a broader model of Discourse analysis that goes beyond 'what is said', to include what is 'known about', reveals a range of issues that should be factored into any interpretation of the ways engineering students' respond to their circumstances. For instance, some students function alone, without a supportive social safety-net; others struggle to cope with the prestige of being an engineering student and many are fearful of the consequences if they do not succeed in their studies.

By paying attention to these other concerns, Case and Marshall (2006) have developed a Discourse model that draws our attention to the impact these other, more affective aspects of personal identity, may have on engineering students. Whilst acknowledging that the origins of this Discourse lies, in part, in the sociopolitical context in South-Africa; Case and Marshall argue that it is a 'cautionary tale' that should be read and considered in engineering faculties throughout the world. For it is in their opinion commonplace for caring teachers in any context to try and reassure struggling students that they shouldn't worry, that everything will be alright. And in so doing, quite unintentionally, feed into a Discourse that sees them (the struggling students) remain in denial of their problems.

In the same conceptual spirit as Case and Marshall (2006), I will also present a Discourse model for understanding the stories students have told about leaving physics*. This model will be presented in Chapter 5.

4.1.1.3 Narrative inquiry

My study is firmly rooted in the domain of *critical* inquiry, and as such employs an interpretative research design. Here I take my lead from Erickson (1986) who uses the term *interpretative* to refer to a family of approaches that includes ethnographic, qualitative, participant observational, case study, phenomenological, symbol interactionist, and constructivist research.

The interpretative research paradigm, offers a range of alternative approaches in which knowledge is concerned not with generalization, prediction and control but with interpretation, meaning and illumination. Adherence to such principles have underwritten, sustained and guided my study, and have informed my attempts to make it credible, trustworthy and to establish findings that will be worth paying attention to.
Interpretative research is perhaps best understood by the characteristics of its methods. Sherman and Webb (1988) provide a summary of these characteristics in suggesting that it:

> [...] implies a direct concern with experience as it is 'lived' or 'felt' or 'undergone'[...] research, then, has the aim of understanding experience as nearly as possible as its participants feel it or live it.
> (*Ibid*, p. 7)

Interpretative research then is characteristically descriptive, and represents an approach, which emphasizes 'research as process'.

4.1.1.4 Case study

Case Study is a research strategy that has a long history in both anthropology and sociology (Crossley and Vulliamy 1996). Based on observation, case studies offer an approach, which is firmly embedded in the lived experiences of participants. As Cohen and Manion (1991) put it, the Case Study:

> [...] reduces the dependence of the reader upon unstated implicit assumptions [...] and makes the research process it-self accessible.
> (*Ibid*, p. 150)

A case study is a research strategy that focuses on the single case studied in its own right using multiple sources of evidence (Robson 2002) – in this situation the case of students leaving physics*. Case studies are carried out in a variety of fields, and in each field the case study carries a local meaning. In this context, the context of the case study in educational research, case studies are called for 'when "how" or "why" questions are being posed, when the investigator has little control over events, and when the focus is on a contemporary phenomenon within some real-life context.' (Yin 2003, p. 2).

Some researchers might point out that a problem with doing a case study is that it cannot be re-created, and in this way, one can question the validity of a case study. I argue that the power of a case study is not its predictive power, but rather its explanatory power. If we can explain why physics* students leave, we might be able to generalize this experience and prevent other students falling victim to those aspects of leaving physics* that are avoidable or approachable through educational initiatives. As Bullough *et al.* (1991) put it (cited in Clark 2000):

> Well-written cases – good stories – invite the reader to enter into conversation and to compare their own experience and understanding with that described in the case study.
> (Clark 2000, p. 33)

When doing qualitative research with a heavy focus on interviews, such as mine, it can be very hard to 'give voice' to the participants if you choose to convey their stories thematically by exemplary interview-excerpts. This problem has been named the 'Crisis of Representation' because it raises issues of validity, reliability, and objectivity (Denzin and Lincoln 1994). But:

> [...] there is no clear window into the inner life of an individual. Any gaze is always filtered through the lenses of language, gender, social class, race, and ethnicity. There are no objective observations socially situated in the worlds of the observer and the observed. [...] As a consequence, [...], qualitative researchers deploy a wide range of interconnected interpretive methods, always seeking better ways to make more understandable the worlds of experience that have been studied.
>
> (*Ibid*, p. 12)

If we know and realize that seeking objectivity is a long lost cause, 'giving voice' to the participants of an interview appears to me to be the number one concern. One way of doing this is to meticulously transcribe all interview-excerpts; carefully including all pauses, sighs, every word and every half-finished sentence; so that the transcription is a written representation as close to the reality of the conversation captured by the recording-equipment as possible.

Clearly, a challenge of this approach is that it delivers a representation of the spoken word that renders the participant's speech hesitant, inarticulate, and even incoherent. The experienced reader of qualitative research will automatically compensate for this impression and in this way put an extra interpretational lens onto the process of reading. The inexperienced reader, on the other hand, will at best have to struggle a bit with understanding the excerpts.

Another challenge is to ensure that the excerpts from the interviews are of a suitable length so that they are able to adequately convey the sense of what the participant is trying to say. On occasion, I will have to fill in the gaps with background information.

A different approach to giving the interview-participants a voice, is by constructing narratives or interpretative stories, from the stories told during the interview. In this way, the problem of an incoherent text can be avoided.

McCormack has devised a research framework for the process of developing interpretive stories from interview transcripts, that, in the hands of the conscientious researcher, ensures the result to be both ethical and ac-

countable (McCormack 2000a). In my process of developing narrative representations of the interviews, I have taken McCormack's (2000a ; 2000b) suggestion that this process is taken through two deliberate stages:

1. Viewing the transcript through multiple lenses:
    - Immersion into the transcription process (apart from paying attention to the words spoken, also pay attention to interactional aspects such as power-relations and emotional vs. intellectual responses).
    - Noting the narrative processes used by the storyteller (such as recognizable boundaries of the conversation as found between descriptions, reflections, recollections or stories, argumentations and augmentations).
    - Noting the language of the storyteller (such as paying attention to frequently used words; relationships between self and society (e.g. *of course*, *naturally*); words that assume common understanding and uncontested knowledge (e.g. *you know*); specialized language; and how sentences are said (active/passive voice, exclamations, questions, personal/impersonal pronouns (e.g. *in such a situation I felt/you feel...*), repetitions, false starts, metaphors and so on).
    - Acknowledging the context in which the conversation was held and in which it is sought reproduced as a narrative
    - Identifying moments in the interview where something unexpected is happening (for instance the places that leads us to reconstruct our perception of the storyteller before and after such episodes).

2. Use these lenses to reconstruct the story by rewriting the interview in first-tense, as you would think the story would have been told if it was not incited and lead by the interviewer's questions.

This method should ensure that all those whom engage with the text can 'come to grips with the storied quality of human experience' (McCormack 2000a, p. 285). In this manner, the reconstruction of the individual stories becomes processes of inquiry into cases of individuals leaving physics*. For the interested reader, I have included an overview of the stories I was told, in a way that will allow for an understanding of the individual stories. This overview is presented as Appendix 1.

4.2 Interviews

Interviews are a widely accepted research tool (Kvale 1996), which lie, as Clark (2000) points out, at the very heart of doing interpretative research. As an approach, interviews allow one to gain information about why people act the way they do in certain situations. Clearly, if you want to know why someone acts in a certain way, it is appropriate to ask them directly, thus allowing them to account in their own words for their actions. Finally, I would like to acknowledge that I have always valued this aspect of my research project as contributing to my own academic development.

Typically, interviews are held either on a 'one-on-one' basis, or in groups. Conversations can be held between two persons – the interviewer and the participant; or they can be held between several people – for instance the interviewer and a group of students – who focus their conversation on a chosen subject. The two forms of interviews each have their own advantages (Morgan 1997): The focus-group interview gives insight into experiences that are shared, but possibly perceived differently, by the group of people. It also allows for insight into interactional aspects of the group participating. The individual interview carried out as a dialogue between two people allows for the participant to talk about experiences that might be unique to this person that might not be addressed in less private circumstances.

I decided to initiate my study with individual interviews, not knowing how personal the experience of leaving physics* was for the participants, and stayed with this method. Each told experience turned out to be so different from the other, and the told experiences were sufficiently rich to inform my study, so I did not see an immediate purpose of also doing focus-group interviews. This does not mean that I do not consider doing focus-group interviews in relation to attrition a powerful method, but rather, that in such a case, the purpose of the study should be somewhat different from mine.

In terms of form, interviews are characterised by different researchers in different ways. Robson (2002) provides a framework, which I found particularly useful. Firstly, interviews can be carried out as structured conversations, where the questions that form the subject of the conversation are pre-defined in a way that requires simple and concise answers. A second categorisation is of semi-structured interviews, where the subject and the direction of the conversation are pre-defined but the intention is to let the conversation flow freely around the subject being discussed. And finally, there is the unstructured interview that might have an overlaying theme, but is otherwise allowed to develop as it might. Described in these terms,

my interviews were really a combination of both semi- and unstructured ones. So while I entered each interview with a set of predefined questions, these functioned as no more than a set of 'markers', which would allow our conversations to develop in a way that was appropriate for my research question.

4.2.1 Interview protocol

I designed an interview protocol to ensure that the interviews, while being conducted, matched my research objective (Gray 2004). My objective for the interviews was to document the students' stories in a way that would give me an understanding of what informed each student's reasons for leaving physics*. I felt that in order to understand why the students left, I would also need to know why they started, and what they did once they left. In praxis, what I wanted was the aspects of the stories of the students' lives that in any way might relate to their choices.

To meet this objective, I developed an interview protocol in which the themes for discussion were presented in a chronological sequence, ranging from 'background', to 'choice of starting' to 'decision of leaving'. Before I did the first interview, I discussed the interview protocol with my colleagues several times and revised it according to their advice and suggestions. As noted in the literature (cf. Rubin and Rubin 2005), one can anticipate that the interview protocol will be refined as each interview is performed and the interviewer gains insight into the interview-subject. My experience was slightly different, in that the only time I found it necessary to change the protocol was during the first interview, where I decided to ask for an introductory story covering the whole of the student's life relevant to the decision to leave physics*, before discussing the student's experiences with physics*. This was necessary because I found that the students made sense of things not only in terms of what they had experienced in physics*, but also in terms of what they experienced, both before and later in life. The interview protocol can be seen in Appendix 2. This means that all interviews were conducted in roughly the same way, differing only in the amount of attention each theme was given.

4.2.2 Transcriptions

As a rule, I sought to ensure that each interview was transcribed as soon as possible after having taken place. This was intentional, because I wanted to carry my reflected experience of each interview with me to the next one.

During the transcription, I also tried to capture those communicative aspects that would otherwise have been absent in a written representation of

the verbal conversation such as laughs, sighs, intonation etc. (that clues the use of, for instance, humour, sarcasm or irony). I also tried to capture my recollection of reflections and intentions during the interview-situation; my thoughts upon listening to the recordings, and general reflections over the interview process.

In this sense, the act of transcription was as much a process of capturing and processing my empirical data, as it was a process of method-related self-reflection and initiation into my analysis of this data.

4.3 Analytic method

After the first few interviews, it became clear to me that there were elements of the ways in which the students reasoned about the themes of our conversation that I did not understand. To get a grasp of what these issues were, I started cutting the interviews into themes, so as to be able to contrast the same theme expressed and explained by several participants. As these themes evolved, I realized that each theme could not be understood separately, but formed part of a broader whole, out of which a model for understanding students' ways of acting would emerge. The main themes of: 'Choice of studying'; 'Gymnasium/university transition'; 'Epistemology's of learning' and 'Socialization' were augmented by approximately 20 other themes. It is important to stress that these themes were by no means fixed and stable, but were, to varying degrees, fluid; and that it was out of the tentative process of data interpretation and analysis, that the themes merged into what became a 'model for understanding'. That model for understanding is explored in the next chapter.

5 Discourse model: Crafting an interpretational lens

> [Discourse models] are "theories" (storylines, images, explanatory frameworks) that people hold, often unconsciously, and use to make sense of the world and their experiences in it.
>
> (Gee 2005, p. 61)

In Chapter 1 I presented a quantitative analysis of attrition in physics* from data gathered from student records. I used the results to argue that the complexity of the issue could not be adequately understood through just statistical representations of students' characteristics and their related trends, but that qualitative insight was also needed. From this perspective I formulated the following research question:

> When students prematurely leave the physics* programme at a well-established research university in Sweden, what aspects of the culture of learning associated with that physics programme are related to their decision to leave?

Building on Chapter 2, which gives an introductory review of literature representative for the field of PER in which this thesis is embedded and Chapter 3 which gives a review of the literature situated in student attrition in science studies around the world, Chapter 4 describes the theoretical and conceptual framing that I chose to draw on to explore my research question.

In this chapter I will draw on aspects of Gee's notion of Discourse models which are 'oversimplified background subtleties' that:

> [...] allow us to act in the world without having to think overtly about everything at once. In this sense, they are like stereotypes, though we should keep in mind that all theories, even overt theories in science, are simplifications of reality that are meant to help us understand complicated realities by focusing on important things and leaving out some of the details.
>
> (Gee 2005, p. 61)

My aim is to show how I identified the Discourse model that the students participating in my study made use of when they made sense of their decision to leave physics*. The reason that I need to this is that I found it necessary to 'look behind' their stories in order to give richer depth to the answering of my research question. In Gee's words:

> Language allows (and requires) people to be (for a time and place) socioculturally distinctive *who's* and to accomplish socioculturally distinctive *what's*. These *who's* and *what's* are always defined, partially, in opposition to other sorts of *who's* and *what's*, and are always related to models of what count as "valuable" (and "normal") people, activities, and things. Thus, social practices are always inherently "political" in the general sense of "interactions where power, desire, and 'goods' are at stake" [24]

In my research framework, students that leave make sense of the aspects of the Discourse[25] of physics* that made them leave by creating a Discourse model. Through this Discourse model the students make sense of their decision to leave. In order to answer my research question my aim is to uncover their sense-making in terms of the aspects of the Discourse of physics* from which they created their Discourse model.

By identifying this Discourse model in Section 5.2 I will find an anchoring from where a conjecture about the origins of the participating students' Discourse model is made (Section 5.3). In Section 5.4 issues of the trustworthiness of the research are presented, through the naturalistic analogue to the conventional criteria of internal validity, 'credibility' (Lincoln and Guba 1985). This leads to establishing that my conjecture about the origins of the Discourse model is credible in Section 5.5. By this conjecture it becomes possible to relate insights, through narratives, into the aspects of the Discourse of physics* that made the students who participated in the interview adopt their Discourse model. In other words, the students tell me *why* they left, but I want to know what it was in their culture that made them decide that such was the reason. When I know that, what it was in their culture that made them decide that such was the reason, I will have a tool to relate the reasons external to the students: The aspects of the culture of physics* that are related to their decision of leaving. In Chapter 6 I relate these aspects by using a narrative inquiry.

But first I will give a description of how I present illustrative elements of the interviews; in some cases as pieces of narrative that closely resemble

[24] Discourse Analysis: Theory and Method
http://diskurs.hum.aau.dk/english/Seminars/GeeSeminar.htm, accessed 7 June 2007
[25] 'When we write or read, speak or listen, we coordinate and are coordinated by specific identities, specific ways of using language, various objects, tools, technologies, sites and institutions, as well as other people's minds and bodies' (Gee 1996, p. 6)

what Gee (cf. 2005 p. 127) has characterized as '*lines* of focus of consciousness' and sometimes as '*stanzas* of focus of consciousness'[26]. Other elements of the interviews used in this chapter make up what Gee (cf. 2005 p.125) has characterized as the 'macrostructure body parts' of a story. These elements are collated as two 'macro-line' themes, namely *Social Identity* and *Knowledge Economy*.

5.1 Introduction to my way of presenting the data

In the opening quote of the thesis, I give an exemplar of all my interviews, by showing how a student insists that because problems in relation to studying physics* exist, it does not mean that 'it's anybody's fault', but instead a reality that the student himself has to adapt to. In the next section I will present a Discourse model that causes this kind of reasoning by presenting illustrative elements from my data.

The approach I use to present my data and its interpretation are re-formulations of the interviews into first-tense descriptions cut into narratively significant pieces that are relevant to a particular issue(s) being discussed. I call these *narrative constructions*. However, in some instances this re-formulation is done in a way that, to a large extent, still includes the 'raw transcripts'. This is because I felt that this existing form fitted best into my discussion. The constructions resembling 'raw transcript' can be recognized from the inclusion of my own questions and comments as they were stated during the conversations. I also present excerpts from my 'raw transcripts'. These are in *italic* lettering.

Essentially, my choices for the way each narrative construction is presented are done in consideration of the way that best allows the reader to appreciate how I have engaged with the data, part of what Lincoln and Guba (1985) call establishing 'credibility'.

In the beginning of the next section I will propose the Discourse model that the students used. This is followed by exemplary narrative constructions of the seven participating students' stories.

[26] Gee (2005, p.127) explains about *stanzas*: 'The information embraced within a single line of speech is, of course, most often too small to handle all the speaker wants to say. It is necessary to let several focuses of consciousness (which lines represent scan a body of information larger than a single focus. This is to say that the speaker has larger chunks other than single focuses of consciousness in mind, and that several such focuses may constitute a single unitary larger block of information.'

5.2 Reasons for leaving: the introspective Discourse model

When students told me about their experiences related to studying physics* they told a story that looked inwards in that almost all their experienced difficulties had to do with *something about themselves*, rather than *something about physics**. Therefore I started exploring the notion that the students were making use of an *introspective Discourse model* to explain why things were as they were. Put in another way, the students made use of an interpretative social language (or a theory) that says that if something goes wrong, it must be because of *something within the self*. The introspective Discourse model has two distinctive parts – an *it just happens that way* part and a *not being good enough* part. In what follows my intention is to fully illustrate both the Discourse model and how it was enacted in my interviews (with all of the seven students who participated in my study). I do this using the narrative constructions that I described earlier, for each of the participants in my study.

The first story I want to convey is Susan's. According to her, she simply faced realities and stopped:

Susan

> I just realized that I wasn't interested in physics anymore, and more and more interested in languages. I was always torn between languages and physics and mathematics. I was good at languages too, and then I was so bad at physics. I didn't pass that many exams, so I had to leave. Else wise I wouldn't have received more money from CSN.

Susan appears to have reached the practical limits for continuing her studies: economy, interest and ability. But I would like to know why Susan is 'bad at physics*', and why she was not sufficiently motivated by her studies to overcome the economical challenges she had met, by, for instance, looking for some part-time employment. Her answer seems to lie in the domains of interest and ability. Since she was initially interested, what then, killed her interest? Her answer is ability.

Marie's story is a down to earth reaction to her initial experience with university mathematics, which was essentially a school-to-university bridging course. She never even started attending physics classes in physics*:

Marie

> I left physics before I even got there. I took the brush-up course in mathematics, and realized that this was how it was going to be for, well, only for like a full year, but it still seemed too much.

Marie's situation could appear to be rather straight-forward. At her first meeting with mathematics during the preparatory course offered two weeks before the first semester starts, she realized that extensively spending that much time with just one subject was more than she was willing, or perhaps able, to do – even given her initial interest in following physics*. Marie explains her waning interest:

Marie

> I mean, I was interested in the subject, but not that much really. Plus there was the competition. Three or four girls in the programme had already been working with meteorology for the military. They got their education paid for, and since I figured there weren't that many jobs in meteorology, and since the pay was really bad – like seriously awful – I lost interest completely.

Here, the issue of not starting the actual physics* illustrates the start of the introspective Discourse model. Marie now rationalizes her loss-of-interest decision to leave in terms of competition and job-opportunities. In my results chapter (Chapter 6) I will return to Maria's story in a more extensive way.

During the first year of taking mathematics, the computer science programme and physics* start in parallel with one another and people in these two programmes initially have several common courses that they take together. Thomas enrolled in physics* but when the course focus turned to physics he turned to mathematics and joined their undergraduate programme. Here is how Thomas explains why:

Thomas

> I started this mechanics course in the second semester. I think that I took the lab exercises, but in the end I didn't take the exam because I concentrated on a math course instead. So I thought I would take mechanics in August instead. But then I got the idea that I should take another math course in August instead. After the first year I knew that I felt that mathematics was really interesting, so I wanted to study more mathematics. But actually I applied for the ordinary third semester physics courses, but in the end, since I hadn't taken the first course in mechanics, and since there were quite a lot of interesting math courses, I ended up just taking math courses instead.

Thomas continued this way and graduated in mathematics. I do not think that there is anything insightful about his story in that there is anything related to the culture of learning physics* that formed part of his decision making. Rather, there was something in Mathematics that affected his choices. Yet it does not seem purposefully made, the story is one of 'things just happen that way due to the way I did things', which is an integral part of the introspective Discourse model.

Karl's story also has an interesting reflective inward turn:

Karl

> I didn't plan to stop studying physics. I was planning to take a break because I thought physics was too distant from the world. I felt like I was studying something that was separated from people. I realized that I was more interested in doing something that was closer to human beings than numbers and particles and the universe as a whole. So I decided to take a break, and went back to the humanities and studied the history of ideas. But when I was half-way through, I heard about a programme in social science. So I changed my mind and decided that I wanted to work with social studies instead. But it was a hard decision because I had to change my way of thinking about what I was going to do. I have always been thinking about physics, so it wasn't easy. I knew it would take more time to study social science then it would to go back and study physics. Studying physics would have been easier. So my choice was not a consideration with regards to workload, but rather considerations about what I wanted to do. What I wanted to work with.

At one level Karl's story is about conscious choice-making to change study direction from science (physics) to social science (people). While it is positive there is also an introspective wistfulness in the story: It was not an easy choice. And it was a choice embedded in personal reflections of interest, which seemed to be unrelated to the learning cultures that he experienced along the way.

Clas, on the other hand, did not really engage in the decision making – in a way he let it happen and then introspectively justified it afterwards: 'It was just too comfortable'.

Clas

> I started working over the summer as a chef, and then I got offered another job. I never really planned to stop studying, but then I liked

the job. It was just too comfortable. I think I just planned to take a year off or something. I've been working there for five years now.

Clas just drifted away from physics*. He did not intend to, but as time went by, his life became more comfortable than it would become if he returned to his studies. He also gave some insight into what made his life in physics* uncomfortable:

Clas

I did 35 points out of 40 that first year. I just felt that I can't keep up that speed for so long. I thought it was wrong. I think you need to let it sink in. But of course, the physics was pretty basic, but the math was totally new. I needed more time to let it sink in. So it felt kind of pointless at the end I think. That was my main problem.

Clas bring out the second aspect of the introspective Discourse model—one that is embedded in the notion of 'not being good enough'. What is particularly interesting is that Clas draws on both aspects, the 'it just happened that way' and 'not good enough' of the introspective Discourse model. So I went on to ask him if he would have stayed if the pace had been slower:

Clas

No, I don't think so, because I didn't take the decision that I'm gonna stop studying. I was just gonna take some time off. If the pace hadn't been so high, it wouldn't have made any difference, because I think it would have been the same anyway. I would have started working and just slowly drifted away from my studies.

So even though Clas had a problem with the pace, his leaving was still very much embedded in the 'it just happens that way' aspect of the Discourse model and this is more powerful for Clas than the 'not being good enough' aspect of the Discourse model. In other words, needing 'more time to let it sink in', is not translated into action, for example by planning to take longer to complete his studies and thus effectively taking less courses per semester (maybe something like studying half time[27]). But Clas also told me that he was unwilling to consider doing something like that.

Joanna's story brings out the two aspects of the introspective Discourse model in an interesting way. While she also uses the 'just happens that

[27] I have since been told by both a graduate student and a member of the faculty that in practice it is impossible to study physics* at half pace, because of the course-requirements and the fact that introductory courses are only given once a year. But when I look at the student records it does appear as though several students who graduated did indeed effectively study at a lower pace.

way' aspect and the 'not good enough aspect', what is so interesting here is that she uses the 'not good enough' aspect in a way that strengthens the 'just happens that way' aspect (see emphasis in italics):

Joanna

> Gradually I worked more and more and studied less and less. And then it got pointless. When you come over a certain line or boundary, it gets pointless to go [back] to university at all, because you are already so far behind that you can't catch up. So leaving physics was a gradual process for me. *But when I did study, I did do alright [manage okay].*

On the other hand the 'not good enough' also emerged in a negative sense for Joanna – she simply was unable to manage the 'eight to four' part of the culture of learning physics*. And then ended up falling behind:

Joanna

> I could not come here every day from 8 to 4. It was impossible for me. I don't know why it was impossible, it just didn't work. I tried, and it didn't work. I have been a person that studies in the evenings and slept in the morning. I was. Now I am working so you adapt. But it's still hard, but not as big a deal as it was back then though. Back then I didn't 'have to' in the same way as now I am working. And I didn't want to accept that I fell behind if I stayed home. I wanted to be able to do the work at home and still be at the same level as anybody else. But it was impossible. You have to be here every day and discuss the problems with your classmates. I'm sure it can be done, but…

Joanna had devised a study strategy for herself that she still insists on: working at home in the evening and sleeping in the morning. When we talked, Joanna told me that she had previously studied other subjects in other programmes at Uppsala University, and there her strategy 'fitted' the programme. When she started physics* she expected to apply the same strategy, and here the strategy stopped working for her. This makes me wonder if my pointing out that Susan, Marie and Clas could have addressed their problems by studying at a lower pace is naive. Joanna certainly did that, but she found that she could not do it in a mode that left her to study on her own: she needed to join her classmates on a daily basis to avoid falling behind completely.

Anita used the introspective Discourse model to discuss her problems with pace but reaches outside the model to discuss her economy. But even then

it is still herself and not the system that she seeks to account for her leaving. Thus still an example of the introspective Discourse model at work:

Anita

> It felt like I for the first time actually had to think. It was something that you had to switch on from the first day – which I couldn't do. I tried to switch it on, but it took up too much of my time. I realized that this was my problem already during the first term. In the second term I realized that I couldn't continue with these courses because I still had so much left to do from my first term. So everything kind of mounted up as time went on. It became too much so I realized that I had to drop out.

I ask her why she did not redo her first semester and she answers:

Anita

> I think that I was so discouraged that I didn't think that I was ever going to be able to redo it all. I'm not even sure that you can redo it. The only way you can do that, is if you do it without any money. You have to take 15 points during the first year to get money from CSN – which I didn't. So the only way for me to pass it, would be if I only took the exams, which I won't be able to pass if I can't take the courses to actually understand what the course is about. It's a dead end.

I think that Anita's story is quite powerful. Talking with her, I realized that she thought that she had not, during her gymnasium years, prepared herself sufficiently well for university. It took her some time to realize what her problems in the introductory courses were, and when she realized what they were, she thought she could bring this experience with her to the following courses and do better. What she found, was that her success in the following courses depended on her success in the previous courses. In effect, she experienced that even though she spent a full year studying physics*, she saw herself only being allowed one chance of 'catching the ride', and that chance was presented to her on 'day one'. But she did not metaphorically run fast enough to 'catch the bus' and neither did she know 'how to catch the next bus' because she did not know if there would be one. This made it impossible, in terms of economy, to learn from her mistakes. I asked her if she thought that this situation was fair. Again, notice how her response is within the introspective Discourse model – there is no help-source expectation beyond herself:

Anita

> It would have been nice if someone noticed that I had problems at the end of the first semester, but no-one did. But there's no way that

anyone could have. I mean, you have different teachers in every subject, so you would need another person to go through every person's grades to see if they have passed, and then ask them if they want to go on, or what they are to do. And there's no way the university will have the money for that.

What I find most interesting in this interview Discourse is that I felt that there were plenty of openings for Anita to feel victimized. But she did not use them. Instead she pragmatically decides to study somewhere else, simply because:

Anita *[...] I understood that physics wasn't something I was meant to study.*

With this narrative construction, Anita voices a perception that I found common amongst the students which is another component of the introspective Discourse model. This perception is that there is a certain inherent ability required to successfully study in physics* and if you do not have that inherent ability then that is just how things are. In effect this notion, that you are / are not conditioned for studying physics*, carries both the 'it just happened that way' and 'not good enough' parts of the introspective Discourse model. For example, consider how Clas formulates it:

Clas

If you study history you don't come to a point when you understand that this is not meant for you to study. If you study math or physics you feel it quite obviously.

I embarked on my research project by after reading a North American inquiry into student attrition from STEM, in which it was stated that 83% of all the science and mathematics 'switchers' they had interviewed complained about 'poor teaching' (Seymour and Hewitt 1997). Only one of the students that I talked to ever mentioned poor teaching and then quickly explained how it had been satisfactorily resolved. Frankly, I was surprised by this difference in the Discourse models. The American students in the STEM study tended to voice issues of 'leaving' towards something external to themselves, such as poor teaching, while the Swedish students in my study voiced issues by taking on an introspective Discourse model. In other words, they turned the issues inwards towards themselves to find reasons for why they left physics*. The purpose of the next section is to present my understanding of the 'reality' that the introspective Discourse model is embedded in for the contemporary society of young Scandinavians.

5.3 Origins of the introspective Discourse model; Conjecture

The chapter so far has been focussed on providing insight into what and how aspects of the introspective Discourse model. What follows will focus on describing two of its 'macro-lines' (cf. Gee 2005, p. 132) as a way of exploring the possible origins of the introspective Discourse model. To do so I will draw on other relevant research and my experiences with my study interviewees. This will also provide insight into some of the details and subtleties that I draw on when I present my results in Chapter 6.

5.3.1 The social identity macro-line

In order to explore this macro-line I need to first introduce the following Scandinavian work dealing with of the 'reality' that the contemporary society of young Scandinavians call upon in their social identity formation.

The Swedish sociologist Jonas Frykman (2005) analysed and contrasted his studies of the 'new pedagogy' of today's Swedish primary education with his and his colleagues' recollections from school in the 1950'ies. Frykman concluded that because the school has become increasingly 'de-ritualized', children tend to form more of their identity outside of the culture of school and then bring these back into the school (a metaphorical external force acting on the system). This means that the object of schooling is increasingly about *making persons out of pupils*, instead of *making pupils out of persons* (Frykman 2005). The distinction here becomes important if one tries to imagine the role that education is given in a person's identity formation (cf. Gee 2005): education becomes one of many means to forming a social identity, rather than letting the social identity grow from within the culture of schooling.

In Denmark leading educational researchers appear to have come to a similar conclusion, by noting that the old question '*What do you want to <u>become</u> when you grow up*'? that is typically in the minds of the young has recently been changed to '*Who do you want to <u>be</u> when you grow up*?' (Illeris et al. 2002). Further, Schreiner and Sjøberg (2005) in Norway chose to interpret results from the Relevance Of Science Education project using such a perspective. In addition, a recent study of students' reasons for choosing physics, physical engineering or physics teacher-education all points towards the same reason: because of an interest in structure of nature (Rødseth and Bungum 2007). The peculiarity of this result is that the engineering students also choose that reason over all other reasons, including the possibility of ticking the box: 'because of an interest in technology'

Thus, because the students are more concerned about their own culture than the culture of others the interviewees were not, for example, keen to talk about the social identity widely stereotyped as 'nerd'.

I	*Is there a certain kind of people that... maybe nerd is a good*
Clas	*Nooo... [laughing] ...ehm...*
I	*Was there some personal charact*
Clas	*nno!*
I	*that makes you*
Clas	*no it wasn't.*

Clas blankly refuses my suggestion that 'nerds' have anything to do with his leaving the studies. He does not even want to let me finish my sentences. I can only think that that is because he knows exactly where I am going, and he does not want to go there with me.

With Joanna I tried a less direct approach. I had learned that introducing the term 'nerd' was not a productive way of approaching issues of contradicting cultures, so I assumed that maybe 'the nerd' was not a contextualization cue shared by Danes and Swedes. (A contextualization cue has been defined as 'any feature of linguistic form that contributes to the signalling of contextual presuppositions'. (Gumperz 1982, p. 131)' (Wilson 2004, p. 2). So I tried introducing the issue by using another contextualization cue that I *thought* was a stereotypical personage that most people in Nordic countries would agree on disliking – the banker.

Joanna	*Maybe I felt also, that I knew less than the people I was studying with, and then it's difficult to take a leading place in your group – which I guess is what I prefer. And if I could study, or do sort of work only with me, then it's not a problem. I always do what I think is best. I guess*
I	*Yeah, now we are getting somewhere. I mean, this is what I would like to talk about. So you do remember the groups?*
Joanna	*I'm just giving you a 'generally of me'. I guess I could have...*
I	*So what you just told me was: If you could have remembered, but you can't, so you would expect that that would have been your problem knowing yourself now?*

Joanna	*Yeah and I think I remember that they were, that people were better than me. Which of course is always a problem.*
I	*and you wanted to take the leading position. It wasn't that they wouldn't let you…? Participate…?*
Joanna	*No I don't think so… … But I think it's only a problem of me. Not of them…*
I	*mhm…*
Joanna	*I couldn't catch up…*
I:	*Is there a certain kind of person that you don't like? Like: 'oh I hate that kind of people'?*
Joanna	*… … hmm… …*
I	*You like people working in a bank for instance?*
Joanna	*yeah sure… I don't know what kind of people works in a bank. My bank-man is a really nice man. No I don't think so, I don't think I have problems with people generally.*
I	*… Do you complain about people, if there is someone you don't like, to other people that you know already?*

Using a 'banker' instead of a 'nerd' clearly did not work either[28]. It confused me. When I asked Joanna what she did to get to know her co-students, she bluntly proclaimed that she did not want to get to know them. I thought of that as a clear indication that she saw herself in an opposing relation to the others. I tried to get her to explore this, but she was unwilling to do this. She perceived it as pointless to look at herself as being in an opposing relation to others, because the best possibility for changing things comes from within oneself.

To answer why Joanna and Clas refused the stereotyping of people as a Discourse model, or even to understand why the outcomes of my interviews are mostly situated in the introspective Discourse model, it is necessary to further develop my interpretational lens through which to view what was said.

[28] Even though it does not influence what I wish to convey by bringing up this interview excerpt, I can imagine how my mentioning a banker can appear puzzling to the reader. Therefore, I feel that an explanation is in order: I realize now that using 'the banker' as a contextual cue, was assuming the contextual presupposition to be a universally disagreeable personage, that in reality takes people of a likeminded political persuasion situated somewhere to the left of naive ideology. In other words: Using 'banker' was stupid.

At first glance, an unwillingness to blame 'the powers that be' for one's own personal failures can appear an acceptance of educational authority being by default 'good'. But that does not match with our contemporary view of the postmodern youth as being anti-authoritarian (Lash 1990).

Another interpretation, then, could be in terms of democracy. Seeing that a majority of people thrive in a given environment automatically makes one, as a democrat who believes in the rule of the majority, accept the environment. This interpretation is still not quite in accordance with the premise of postmodernism, that everyone is justified in having their own rights. Thus I will now explore a merger of the two.

Merging the above two aspects – democratic and postmodernistic thought – means that if a person wants to perceive his or her own 'choice' of identity as a fundamental liberty, he or she needs to accept others' choices based upon exactly the same premise. If a person experiences a conflict with others, this conflict is personal, and not necessarily an experience shared amongst the people involved – and vice versa.

This, now, is a fundamental doctrine of another product of postmodernism, namely phenomenological thinking: 'the way problems, things, and events are approached must involve taking their manner of *appearance to consciousness* into consideration' (Moran 2000 p. 6). For example, if one person experiences harassment, then that experience exists in its own rights, and does not have to be proved or disproved, but just accepted and addressed. Conversely, if other people do not experience themselves as the 'harassers', this experience also has its own rights. The person cannot be blamed, unless he or she is unwilling to consider changing behaviour.

The point I am trying to make is that if a student experiences incommensurable aspects of interpersonal relations, the student will, by default, also expect this experience to be subjective, suitable for introspective rationalization, as opposed to an expression of an inter-relational problem that should be addressed publicly.

In a perfect world, truly believing that your own identity-formation should be given room in the world would then require that others' are also given room for theirs.

Now, in relation to my Discourse analysis one consequence is that there is a significant difference between the following two statements:

1. The perceived culture at physics is not commensurable with the perceived culture that defines 'myself'.
2. My culture is not commensurable with the perceived culture that defines physics*.

From my Discourse analysis the first statement appears unthinkable for the people who leave, while the second statement is a prevailing aspect of all the participants' stories. The two statements are alike in that the *perceived culture that defines physics* is static and in a way, monumental, and so is *the perceived culture that defines me*. However, what makes them different is the reflection-direction between individuality and environment. And this leads to either of the following two statements: if you want to resolve the problem stated in (1) you will have to change the culture of physics, while resolving the problems stated in (2) will require a process of concinnity[29].

When I set out to interview students, I wanted to use Discourse to 'dive into' the kinds of reflections that may lie behind statements like (1), but instead all the students opened a Discourse model that held something like (2).

In the following I will present narrative constructions in a form that resembles conversation. These are *not* verbatim transcripts.

Again Clas had a concise way of illustrating this issue:

I	Good, but anyway, do you think that there's anything we missed? Something that I should know?
Clas	No, I don't think so... Guess you asked the questions that you need. But... I don't think ehm... Oh, it's so individual. Some people make it, some don't. It's just ehm. You can't say that there's something wrong with the courses or with the pace, because some people make it. Maybe you are not meant to study that.

Note, that this excerpt is from the stage where I was about to finish the interview and wanted to give the participant a chance of raising issues of their own. Clas decided to take up a position of support for the institution. He did not want me to give the impression that he blamed the institution, because to him the blame was clearly with himself.

[29] The deliberate act of conscientiously adapting to the external.

5.3.2 The knowledge economy macro-line.

This macro-line is an approach to a conjecture towards understanding the aspects of motivation in relation to the origins of the introspective Discourse Model.

It appears that the introspective Discourse model is typically centred around the subjective self in Nordic society. If this is an aspect of post-modernism, which might be true, then it is a form of self-centredness or egoism that should never be expressed at the expense of other egos. Identity formation is a purely individual struggle and in this sense falls as close to egoism – a struggle that appears almost solipsistic in nature. Identity-formation has in that sense seemingly left out all connections to solidarity-thinking in that the formation of the subject is not put in relation to the formation of other subjects. Instead the project of identity is allowed a sovereign freedom – it can develop any way, just as long as it does not harm anybody else. This principle is remarkably similar to Spencer's law of equal freedom: 'Every man has freedom to do all that he wills, provided he infringes not the equal freedom of any other man.' (Spencer 1851, p. 103).

In that sense, the project of identity is closely related to the ideology of cultural liberalism:

> The object of this Essay is to assert one very simple principle [...] that the sole end for which mankind are warranted, individually or collectively in interfering with the liberty of action of any of their number, is self-protection. That the only purpose for which power can be rightfully exercised over any member of a civilized community, against his will, is to prevent harm to others. His own good, either physical or moral, is not a sufficient warrant.
>
> (Mill 2002, p. 8)

But there is an aspect of including liberalism that makes this discussion somewhat more complicated. If we explain the ways students reason about leaving physics by an identity-construct that draws on postmodern and liberal thinking, Seymour and Hewitt's finding that roughly 80% of American science leavers complain about the quality of education becomes problematic. If you would expect to find processes of identity-formation inspired by liberal ideologies, it should be the United States. But in the United States, a country in which the term 'welfare-society' describes a failed society[30], all identity thinking must in some ways be related to materialistic considerations as well. Meeting the costs of education and living

[30] The American meaning of a welfare-society as a society where everyone is in need of social relief, is in stark contrast to the Scandinavian sense of a welfare-society characterized by prosperity. Fundamentally the two meanings of 'welfare-society' are the same, but the ideological interpretations are not.

during studies must be a considerable concern for students. In Scandinavia the immediate costs of education and living are covered by the government – which is why this materialistic aspect, characteristic for American students, can be removed completely. Instead, the liberal attitude towards identity formation must be seen in terms of mastering a *knowledge-economy* rather than a *monetary economy*.

In a knowledge-economy, what is bought is ability and competence and what is sold is doing and practice[31]. In this sense we have an explanatory model for students' way of thinking: If they want ability and competence from education, they will have to comply with the doings and practice at the institution of education. Conversely, if a subsequent employer wants to buy a person's competence and ability the employer will have to comply in relation to this person's doing and practice. More specifically, this means that if a student finds his or her own identity in accordance with the practice at the institution, he or she will gain a competence that in all probability will be in accordance with the doing and practice of a likely employer.

This actually means that we have a built-in paradox for the knowledge-economy, when students are described as consumers, as per Hovdhaugen and Aamodt (2005): it becomes reactionary and resistant to change. The cultural aspect is self-feeding or self-contained and not open to change – because change will come at costs of investment or speculation rather than consumption. In an investment situation there are aspects of risk and expectation. Consumption, on the other hand, is buying a commodity where both buyer and seller know the worth. In consumption, regulations have been introduced to protect the consumer. Should the consumer feel mislead in establishing the worth of a commodity, the transaction can be annulled.

This is not the case for investment and speculation. The paradox exists in describing students as consumers, and at the same time describing a thriving society, fuelled by education (i.e. students), that we can see is not reactionary and resistant to change. Either the students do not behave as consumers in a knowledge-economy, or the students who do, are not the ones that fuel the society. But if we indulge in the notion that those students who represent a majority of attrition are actually consuming education, my description of the knowledge-economy also introduces another problem to overcome in the quest to reduce attrition in higher education.

[31] What the currency of the knowledge-economy is, is still an open question. Peter Fensham suggests that the currency is information, while I would maintain that information is the product.

Bowden and Marton (1998) argue that higher education is about preparing students for an unknown future. Thus the consequence of specializing educational programmes within strict paradigm-lines might be that the educational value becomes obsolete by the time students graduate. If teachers at the university teach for an unknown future the knowledge-consumer will find no future in such a teaching situation simply because the consumption of knowledge requires a strict contract of cost and worth. Instead, a learner has to adopt an attitude that can be defined as knowledge-speculation and as a knowledge-investment. Parallel to monetary economy, companies who want to maintain shareholders will continuously have to convince their shareholders of the worth of the shares they hold. Similarly, it must be the responsibility of an educational institution functioning in a knowledge-economy to justify for the students, their investment – just as it is required by the students to justify for the society, its investment – as is done through standard requirements on examinations.

In our current Scandinavian society there is a 'home' for the knowledge-consumer, and that might be a sign of a healthy knowledge-economy (depending on your ideological stand). But what if many of the 'consumers' do not know the difference between consumption and investment? Or phrased outside of the metaphor of a knowledge-economy: are the students in search of an identity in postmodernism equipped to do so? Or will they waste their time acting on any little irrelevant whim?

Ironically these questions were questions that were already raised during the time of the Roman Empire, and before I return to an exploration of the issue of 'the knowledge-consumer' in relation to my interviews it is necessary to obtain insight into why the interview-participants tend to actively direct all critique towards themselves.

5.3.3 Accumulative discussion

Drawing on post-structuralism, the following valuable insight into the mechanism that I see enacted by the students that participated in my interviews, can be gained:

> To fabricate one's subjectivity as an object of knowledge is to discover the 'truth' about oneself where whoever guides this process plays an active and powerful role. Foucault (1981) refers to this process as 'confession' [in relation to sexuality] [...]. This process [of confessional praxis] has spread and now encompasses not only sexuality but also health and lifestyle. It has become central in governance of modern society, where externally imposed discipline has given way to the self-discipline of an autonomous subjectivity. Thus "Western man [sic] has become a confessing animal' (Foucault 1981, p. 59). Here the purpose of confession shifts from one of salvation to that of self-regulation,

> self-improvement and self-development. In other words, confession actively mobilises a productive and autonomous subject but one who is already governed and in this way there is no requirement for externally imposed discipline and regulation.
>
> Confessional practices work in the basis that there is something to be confessed, a deep truth or meaning hidden within subjects, which, whilst it remains uncovered, is dysfunctional – these 'truths' can include sin, unhappiness, stress, bad choices, unhealthy lifestyles, to name but a few. However, once uncovered the door to redemption is opened. In a largely secular Western world, redemption increasingly equates to personal development, physical and psychic health, autonomy and emancipation. In other words, confessional practices are understood as the royal road to empowerment.
>
> (Usher and Edwards 2005, p. 399-400)

I find the above citation in convincing agreement with my conjecture on the manifestations of the postmodernistic student in search of an identity. However, I must acknowledge the ongoing discussion about post-structuralism and postmodernism, that 'the two frameworks should not be used interchangeably or treated as synonymous with one another' (Moloney and Fenstermaker 2002 p. 203). Nevertheless, for the purpose of gaining insight into the origins of the introspective Discourse model that is needed for the interpretation of my interviews, I believe that the characteristic differences between postmodernism and post-structuralism are sufficiently miniscule to disregard in this context.

Therefore, I think it safe to presume that the phenomenon of students taking all possible critique of their experience of learning in Physics* inwards, is an act of self-preservation that is enacted by a form of 'confession' that leads to 'redemption' and ultimately empowerment. As another interviewee explained, when I provocatively asked them if she thought it was alright to start on a programme, quit it and then go to another programme, or if it was embarrassing:

> Joanna
>
> Do I think it's alright? Yeah I think it's alright. And no, I don't think it's embarrassing either. I'm not embarrassed. But I guess it's a waste of resources in a way. 'Cause you waste people's time. But I didn't feel that way when I quit. You have to find out what you want as well. And in Sweden we are so privileged, we can just try things out and move on. And it's more about me than about my education, which might perhaps not be the same for people from other countries, where education is most important and not the need to broaden your soul or something.

By further extending Usher and Edward's (2005) depiction of post-structuralism related to Foucault's (1981) dictum, I have argued for the realization of 'The Scandinavian physics* student as a confessing animal' and the aforementioned implications. In Section 5.5 I will show how this realization can be put to use in the form of an interpretational lens for dealing with my interviews. At a first glance, the Discourse that the participants appear to be a part of, could very well be described as the individualist's, in the sense of individualism[32], but individualism is most often contrasted with collectivism. A very recent Danish study of the transition of youth from primary and secondary educations, also finds pupils embedded in a Discourse very much like the one I am describing here (Pless and Katznelson 2007). Additionally they found that these pupils are sensitive to the expectations from adults – they are willing to go very far to comply with directives from educational institutions, concerned parents and frustrated politicians. Such behaviour is not individualistic, but rather collectivistic.

Since I therefore am unsure whether it is reasonable to contrast the Discourse that the participants are situated in with collectivism – as would have been the case if describing the Discourse as individualistic – I think that the term 'pseudoindividualism' might be promising. Pseudoindividualism is related to, but not quite, individualism, and sometimes used in relation to studies of advertisement and consumption, as something that is related to the paradox of individualistic mass-consumption (Goldman and Papson 1996). Ellis (2000), on the other hand, has found a lyrical description in relation to the term that fits this conjecture neatly:

> In deploring capitalist pseudoindividualism where every man "live[s] in the same villa and every man in a different universe," [G.K Chesterton] upholds the medieval guild system as offering a fuller identity to its members than anything found in modern standardization, where "the current tendency ... is to discuss not so much cooks as cookery and not so much clerks as clerking."
> (Ellis 2002, p. 31)

Adopting the term 'pseudoindividualism' in naming aspects of the Discourses that give rise to the interview-participants' use of the introspective Discourse model, along with the 'social identity' and knowledge-economy sub-stories, presents a rough (and rather complex) idea of what that Discourse actually entails:

- Students justify their actions and choices in a way that very much resembles individualism.

[32] Broadly speaking individualism is thinking of and defining oneself independently of others.

- Students' Discourse is imbedded in a collectivist society that finances their education and living.
- Students allow for others to develop their identities in a manner that allows for and does not question the rule of the majority, that is, the establishment.
- Students' thinking is very much embedded in postmodernism/poststructuralism.
- Students' Discourse is in accordance with a knowledge-economy that in many ways metaphorically resembles a monetary-economy.

To borrow a term from Qvortrup (2003), the students navigate in a 'hypercomplex' society in which the only true rules to pay attention to (besides the obvious of legislation) are the ones dictated by the heart of each individual throughout his or her search for his or her individuality; a search that was initially dictated by the school and is later facilitated by education. If one tries to explain one's actions through such a lens, one will, according to my conjecture, be imbedded in an introspective Discourse model.

In section 5.5 I will attempt to establish that my conjecture as to the origins of the introspective Discourse model is credible. But before that, issues of establishing credibility will be explored.

5.4 Credibility

In this section I will discuss issues of quality related to naturalistic inquiry, and how they relate to my study.

In their authorative work, Lincoln and Guba (1985) present methods for establishing trustworthiness in qualitative (naturalistic) inquiry:

> We shall suggest five major techniques [for testing the naturalist's alternative trustworthiness criteria of credibility]: activities that make it more likely that credible findings and interpretations will be produced (prolonged engagement, persistent observation, and triangulation); an activity that provides an external check on the inquiry process (peer debriefing); an activity aimed at refining working hypotheses as more an more information becomes available (negative case analysis); an activity that makes possible checking preliminary findings and interpretations against archived "raw data" (referential adequacy); and an activity providing for the direct test of findings and interpretations with the human sources from which they have come – the constructors of the multiple realities being studied (member checking).
>
> (*ibid*, p. 301)

In the form of a checklist, Lincoln and Guba's (1985) five suggestions are:

1. a: Prolonged engagement
   b: Persistent observation
   c: Triangulation
2. Peer debriefing
3. Negative case analysis
4. Referential adequacy
5. Member checking

Regarding (1.a); 'Involvement over a period of years was a defining characteristic [...]. In most current studies [...] fieldwork is much more condensed, but a period of weeks or even months is still usual' (Robson 2002, p 172). It is hard to define the degree of my involvement, but since I have been working in a focused way on my thesis project for a full year, I argue that I have attained a reasonable level of prolonged engagement.

Regarding (1.b), here I see my quantitative analysis (Chapter 1) and long consequent interview sessions (from 1 to 2 hours each) as providing an adequate level of persistent observation.

Regarding (1.c), triangulation is 'the use of more than one method of inquiry' (Robson 2002, p. 174). I would argue that this is not an attribute that can be quantified for a narrative outcome. Also, the very nature of Gee's (2005) Discourse model has a framing that is multifaceted in that it includes the symbols, language, representation, culture, gender and social identity.

Regarding item (2); peer debriefing was a frequent and natural part of our work in the research group. Furthermore, issues of doing interviews and considering issues of research had a natural place in our frequent, broader research group discussions.

Item (3) does not necessarily make sense given the nature of a Discourse model. A Discourse can involve multiple identities, and conversely, an identity can make use of multiple Discourses (Gee 2005). Thus it is not reasonable to attempt to find negative cases to a Discourse model that is supposed to describe and explain aspects of the Discourse of students who leave.

Regarding (4); Lincoln and Guba (1985) write:

> [The concept of referential adequacy can] be utilized if the investigator will earmark a portion of the data to be archived – not included in whatever data analysis may be planned – and then recalled when tentative findings have been

> reached. [...] such materials [...] can also be used to test the validity of the conclusion. Sceptics not associated with the inquiry can use such materials to satisfy themselves that the findings and interpretations are meaningful by testing them directly and personally against the archived and still "raw" data. A more compelling demonstration can hardly be imagined.
> (*ibid*, p. 313)

In the Sections 5.2 and 5.3 a wide array of my empirical data is presented which I use to identify and gain insight into the introspective Discourse model, but I have left a concise part earmarked for 'a referential adequacy check' in Section 5.5. This part I will use to offer my conjecture into the origin of the introspective Discourse model credibility. Further credibility may be constituted by the reader from the full interview-transcript that I provide in Appendix 3.

With regards to the final item in Lincoln and Guba's (1985) list of suggestions for credibility checks that is labelled (5): I decided that to bring back the participants to ask them about my interpretations of our interviews was not a good idea. The social interaction for the interviews was complex and involved a great deal of trust building. Some students might have felt they shared experiences that they found difficult to discuss. To bring them back to their stories in an analytical mode seemed to me to have the danger of making the process seem technical and insensitive. So I did not share my interpretations as item (5) calls for.

In the next section I have engaged in the 'referential adequacy' check, and with that, explored the last of Lincoln and Guba's (1985) five credibility checks.

5.5 Credibility of the conjecture

5.5.1 The reasons for the 'nerd' discussion

To bring out the credibility aspect I need to return to the discussion of 'nerds'. When I considered strategies for approaching the problem of attrition as something connected to the culture at physics* through interviews, I expected that talking about issues of 'nerds' would be a natural and central part of the interviews – a way to overtly confront aspects of stereotypes in the Discourse model that I assumed the student would make use of. This assumption came from a study very similar to mine that I received before I started my interviews. This study involves physics students at the University of Copenhagen and is entitled: 'Do you have to be a nerd to

become an able physics student?' (Bentzen 2006, my translation). To give a specific example of what I expected from my interviews with physics students who left the physics*-study, I will bring an excerpt from one of Bentzen's conversations with a physics student who left the programme in Copenhagen:

> "My idea was to become the first, this sounds kind of self-satisfied, but become the first nerd... with style... You can still keep up, you still have a good time, you know, a social nerd or whatever. But that is something a lot of people can do... I mean, they all have a good time out there, and at the same time they study what they are required to. But that kind of nerd [the nerd with style] wasn't really needed. It was there already in some way... the type that I wanted to be... Yeah, nerds doesn't really exist anymore, they still exist but... Yes, you can still find some small wimps constantly sitting in front of their computers, those are probably plentiful, but there are also other types, that are just normal and who have a good time. And who can complete their studies at the same time."
>
> (Bentzen 2006, p. 50-51 my translation)

Bentzen's participant did not mind talking about 'nerds' even though his actual experience was that there were no 'nerds'. He assumes they were there, but we do not know if he actually met any – which is why the excerpt shows that Bentzen's participant did not have any issues with stereotyping.

5.5.2 Karl's discussion about 'nerds'

Bentzen is able to convincingly conclude from her empirical data that issues of 'nerds' play one of the many possible roles in the students' negotiation of legitimate participation in the physics student communities (Bentzen 2006). Whereas the students that I talked to consistently refuse to discuss stereotypical personality traits. I consider such a refusal to be the case when talking about 'nerds' is claimed to be useless in relation to experiences. Let me give you a rather lengthy example of a part of the conversation that I had with Karl. The example has been re-composed to enhance clarity, but only slightly (see Appendix 3):

Karl	If you ask people why they chose physics, most people will answer that it is partly the problem solving, partly the interest in the subject and partly the prestige.
I	Is it prestigious to be a physics student?
Karl	Yeah, if you compare to being an art student anyways.
I	But an economics student then?

Karl Yeah, if you compare them, I think being a physics student ranks highest – both in their own minds and others too. I mean, physics students are the brightest people, if that is what you measure.

I Yeah, if you measure by on IQ standard maybe.

Karl Yeah.

I But how about social intelligence?

Karl This institution harbours so many people. And every one knows that there is absolutely no conflict between social competence and physics. So I and many people I know who study physics are socially very pleasant people. I never experienced it as a conflict and I didn't think there was one when I quit studying.

I I think that is a major cultural difference between Denmark and Sweden. Because I've always been a bit 'ashamed' of telling people that I was a physics student because it would brand me as a nerd. But I haven't met a Swede yet who's talking about nerds, and you don't either.

Karl No, but I've never really thought about nerds. I mean, if you go back to gymnasium at the natural science programme, already there people are kind of the same kinds. But they don't think of themselves as nerds. Rather: 'We are just the ones who are going to do this.'

I But don't you have nerds within that grouping? The natural science programme is, as you said yourself, a good place to go if you want to continue university studies. You can get in anywhere after the natural science programme. So both people who knows what they want to do, and people who are a bit more academically 'fluffy' go there.

Karl Yeah…

I But I mean, have you ever met a nerd?

Karl Nerd is an American word. It is not as obvious in Sweden. I mean, I had many people in my class who were into computers and programming and sitting at home building little robots in Lego. That was not uncommon, but I never experienced that there was any big relation to social competence. Perhaps some people did look down on them, But I'm not sure I ever experienced that. But if someone did look down on these people, I can't really say that I care.

I Maybe it is just an American term and maybe also just a Danish term. But I mean, I know what a nerd is. It is a person who is interested in science and has weak social competencies to the brink of almost seeming stupid, but who also shows signs of another form of intelligence when succeeding well in physics. And maybe this weak social side is actually what is needed to be able in physics, because then you can spend your time at home doing the stuff, and when you actually meet with other people who share your interest, then you can keep on working without talking about different stuff then the work at hand.

Karl [laughing] Yeah, that might be so, but not in Uppsala. There are too many people studying physics or technology in this building for you to be able to stereotype them. I mean, probably there are people who have social problems, but if you have social problems, you have social problems. Perhaps more of them study physics, but I never thought and there is no absolute connection between studying physics and being one of these people. Perhaps there are people studying economics who think so, but it is not something that a normally developed person would automatically assume. Just because you study physics, you cannot be put in that box.

I [laughing] I agree with you, it is not that at all, but the reason that I am talking to you and not some guy who is studying economics, is because you've been here, and you've seen how it is.

Karl Of course there are people who have problems socially, and perhaps because of that are more accomplished in physics, and perhaps even for that reason chose physics as their subject. But I don't think that makes people make the connection between physics and having that personality. Not to a degree that affected my decision not to study physics, cause I don't see that link and I don't think that other people see that link that strong. And if they do... I don't really care about people who do see that link, because then they make a stupid link and I would simply disregard that.

I [laughing] god damn it that became a bit complicated. But in effect, what you are saying is that the reason you left was not because they were nerds and you weren't?

Karl [laughing] I don't think that other people see that connection, so that could not have effected my decision. No, absolutely not.

I bring up this short narrative construction of our conversation for many reasons. The first is that it is, by far, the longest coherent expression of considerations into issues of 'nerds' that I was able to obtain during my interviews. The second is that it actually seems to be representative of what other people have said – as can be seen from the two extracts by Clas and Joanna in Section 5.3.1 and in what Marie said when I asked her what she thought about the other people who studied physics:

Marie Well, they were, like, brighter people I would say. I mean, there were nerds of course, but then there were, like, sport jocks, and these meteorology girls, they were really pretty too. But they were all like regular people too.

Marie, like Karl, feels that people in physics* are generally brighter than other people, but as opposed to Karl, she acknowledges 'the nerd' right away. At the end though, she maintains like Karl, that there are all sorts of people studying physics.

5.5.3 The social dynamics of the discussion with Karl

The primary reason for bringing up this narrative construction, though, is because of the dynamics of our discourse at both covert and overt levels. First of all, when I asked him if he had ever met a 'nerd', and he answered that he does not care if anyone ever looked down on people who could be classified as such, he straight away made me feel dismayed that I brought up stereotyping as a tool in the interview. What happened at that instant in the conversation was that our power-relation suddenly shifted. As the interviewer, I am supposed to decide what I think is interesting for my research, but suddenly Karl makes a statement in which he states what he not only thinks is interesting, but also what is worthwhile. Of course we continue the conversation in a decent, even congenial tone, and we laugh interchangeably but, as I hope is evident from the conversational piece presented, something else is going on under the surface.

Karl tacitly tells me that I am 'out of bounds' and analytically unsophisticated. I, in my role as the one who explicitly brought up the term 'nerd', am similar to the people he describes as 'not normally developed' and 'stupid'. On the other hand, at an interpretational level, he, by way of

phrasing his description of his experiences and beliefs around 'at least not in Uppsala', does not dismiss me completely. Rather, he accepts that 'nerd' can be used descriptively for attributes where I come from, whereas he is talking about Uppsala University where he comes from, and where things are different. But if I return to the level of what is actually being said I honestly think that he is unjust in dismissing the issue of 'nerd' so readily. I am not pressing the issue, rather I am following his own attitude towards describing issues in physics. This attitude becomes apparent when Karl says that he and other people think that people studying physics are more intelligent than people studying other subjects – from there I appear to be trying to establish what that intelligence is by introducing social intelligence as a contrast to the so called intelligence quotient (IQ) rating. Of course I have a covert agenda to reveal the negative, rather than the positive, aspects of the physics* experience, but the person I am speaking to is not unintelligent; quite the contrary. I think it can safely be presumed that he has figured out my agenda. He has also figured out that if he does not explicitly deny it, I will ascribe the negative aspects of his experience of physics* he describes, to his choice of leaving. It is in this context I will apply my conjecture on the origins of the introspective Discourse model and interpretational lens developed in section 5.3.

Karl hotly rejects the idea that there could be any connection with his choice of leaving and the difference between physics* students and other people in terms of any hypothetical social deficiency. Yet, he readily claims that physics* students are more intelligent than other students. Now, I ask myself why?

To answer that question, I have reconstructed my conversation-turns, -changers and -initiators, and for clarity given his answers in an extremely condensed form, leading up to the point in our conversation that I presented on the previous pages of this section:

(1)	I	How did a normal week in physics* look for you?
	Karl	I just went to the lectures and talked a bit with the others. Then I went home to study , go to choir or do sports.
(2)	I	Where did you meet the people you worked with?
	Karl	During lunch, and at the nollning.
(3)	I	Why did you join the nollning if you had friends outside of physics*?
	Karl	Because it is nice to know the people you are around.
(4)	I	Why did you switch studies?
	Karl	Because I'd rather work with people than with physics.

(5) I Was choosing to study in the humanities an easier choice compared to choosing physics*?

Karl Yes. I didn't consider the workload but what I wanted to work with at the end.

(6) I You left because you felt that Physics* was removed from the world in that it didn't have anything to do with people, didn't have any practical implications?

Karl Removed from the world yes, but practical implications no. I know that physics has a lot of applications that people use every day in life. So if I wanted more practical implications I could just have changed to engineering. But I wanted to get closer to people – work with people.

(7) I Are you talking about working with people every day when you go to work, or are you talking about working with people in the sense that people are what you work 'with'?

Karl Both, but the best explanation is probably that people should be the subject of my work.

(8) I I'm trying to understand why you actually started studying physics.

Karl [long sigh]

(9) I I'm trying to sum up my understanding of it and what you wanted it to be.

Karl I was good at physics, and always interested in the subject. (His explanation continues in the narrative presented at the beginning of this section)

Prior to cue (1) our conversation was about establishing the participant's past. The reason that I gave these cues is that I wanted to indicate where I gave myself away in a way that made him feel he had to ensure that I did not think he left because the other people were 'nerds'. Because, as can be seen from the presented constructed narrative, this is an issue he himself brings up, whereas I 'merely' asked what he thought of social intelligence in relation to physics* students. I want to figure out if his defensive attitude is a form of denial that actually points towards a truth. However, because I in cue (7) show a specific interest in understanding if he wanted to work 'with' people or 'on' people, I do not think that there exists a truth hidden by denial. Rather, when I asked him that question, emphasizing the difference between working 'with' people and working 'on' people, I indirectly told him that his answer would open two possible scenarios: (a) The obvious scenario that he changed because he wanted to work 'on'

people in the way you do when you study issues directly related to people, or (b) that he changed because he wanted to work in an area where he would have colleagues. If (b) had been the actual explanation for his decision to change, it would have been natural to raise the issue that you also have colleagues when you are a physicist, and whether something about these colleagues or their practice would be disagreeable to him. If I had not had a tingle of an expectation that (b) could be the possible outcome, I would not have given cue (7). But since my agenda was to uncover aspects similar to (b) I also gave it away by indirectly suggesting that scenario.

Thus, the conclusion for this piece becomes that he had figured out that if he was not careful, I would interpret his statement of 'I wanted to get closer to people – work with people' along scenario (b) by a logical deduction that could go along the following lines:

He changed in order to work with people.

Therefore

He did not work with people when he was in physics.

But that is untrue (both in reality and in his mind) because:

(I) there were people around him in his studies;

and

(II) he had previously told me that his grandfather had used his physics education in a political capacity, and thereby demonstrated that the immediate boundary for 'working with people' could easily be extended.

Therefore

It was not people *per se* he did not work with, but people different from the people he wanted to work with.

When I then asked him about intelligence in terms of social intelligence and 'nerds' in physics* he felt that he had to avoid my possible misinterpretation, which is commendable. But curiously, he did not, in the same way feel the need to correct or help me when I showed signs of not understanding motives that are related to him personally – his subjective self. For instance, at cue (8) he reacts with a very long sigh.

Expressed through a cliché, my interpretation from the whole conversation as to his reasons for leaving could be: 'It is not you. It is me, and honestly, it is more important that you understand this, than that you understand what it is about me that made me change.'

5.5.4 The unmasking of the 'hidden agenda'

But as I press our conversation to approach questions concerning 'what it is about him', this understanding will invariably have to be put in a referencing context: If you describe what you are, you will also describe what you are not. But he resists:

> Karl The others being nerds, and I not, raises a totally different issue. I was always closer to being a nerd than I was to being a cool guy. I've never been the cool guy. Many of my friends were what you would probably describe as nerds. I have been thinking about social issues a lot, so of course I have been affected by the issues of nerds and school and so on, but it is my experience that that sort of grouping isn't as strong in Sweden as it is in other countries. But in this sense the grouping does exist. Because there is always a grouping – a labelling. If you are the smartest guy in class for example, you will be labelled as being that, and if you spend a lot of time studying, people will always judge you for it or see a reason for it. And of course that exists in Sweden as well. I've always been one of the guys who did good in school, and therefore I never felt that I've been one of the people thinking of other people that they are nerds. On the other hand I never really felt that I was a nerd myself either. Of course I had social problems. But when you are growing, everybody have social problems in the sense that they are insecure and so on – and my problems were in the same way and never social problems in the sense that I was bullied. So I've never felt that I was thought of outside as a nerd. I've never been the nerd, nor the leader of the group – sort of just in between. In that way I have never defined myself in this sort of context – of being a nerd and outside. It is a silly distinction simply, that only leads to harassment. So if the rest of the group does not indulge in harassing behaviour then there will be no need for making that sort of distinction between people. In högstadiet we were all sort of strange people running around, but in gymnasium... In a sense this is probably the advantage of this segregation that occurs when you have to choose between natural science or social science and the rest of all the programmes. You get the natural science students and they are all in a way interested in studying and going to university. Not all of

them perhaps, but most. So then you don't get the environment where it is alright to pick on someone because he is good in school.

After this, I try to confront him with his earlier statement, that there are too many people in physics to make distinctions of physics* students in clear-cut archetypes. And he answers:

Karl	I mean, you have to have the qualities that all people need to have to succeed. But I don't think you have to be brilliantly smart in physics. I think you can compensate by working very hard for example. If that is what you are asking, because that might be what you are asking.
I	I'm not trying to cloud my questions.
Karl	No, but no, ok. But that could be a question: Do I think that people have to be smart to become a physicist?

And here he admits that not only has he figured me out, he is also actively trying to unmask what he expects is a hidden agenda. Some might point out, that if the interviewee has decided that the interviewer has a hidden agenda, and is trying to unmask such an agenda during the interview, then the interview has failed. However, my intention is that this reaction underlines the credibility of the conjecture as to the origins of the introspective Discourse model. This is because I use these components of the interview-session to unmask the interviewee's persistence on central aspects of the introspective Discourse model and am able to explain this persistence in the terms of the conjecture – as when he insists on using the term 'nerd'.

Furthermore, I think that it is important for this discussion to note how Karl in principle objects to the term 'nerd', but not in practice. He has consciously tried to avoid thinking of people as stereotypes, which implies that thinking of stereotypes is an issue, an issue that he dismisses. This does not mean that the stereotyping does not exist in his world though: people who see the stereotypes or are stereotyping are stupid. Which in itself, curiously enough, is an act of stereotyping – but from Gee (2005) not surprising.

As I said in the beginning of this section, I felt dismayed when Karl devaluated my suggestion, in terms of contrasting IQ with social intelligence, of trying to understand his claimed intelligence of physics* students. And there is a good reason for that: 'The Conversation in a research interview is not the reciprocal interaction of two equal partners. There is a definite asymmetry of power: The interviewer defines the situation, introduces the

topics of conversation, and through further questions steers the course of the interview.' (Kvale 1996, p. 126). Kvale is not saying that the interview 'ought not to be', but says that 'it is not the interaction of two equal partners. When Karl broke the convention of the interview, he also eroded our mutually established identities of interviewer and interviewee. As I mentioned, our tone continues congenially, but when I listen to the recording both our laughs appear slightly strained and somewhat 'cool'. By using laughter we both compensate for the sudden feelings of insecurity that resulted from the minor breakdown in the convention. The question is not whether Karl knew he broke a convention, but why he did so? My analysis reveals that Karl needed to make sure that I did not interpret his answers as a critique of the other physics* students, but instead understood that his change was a result of his personal needs. Karl's need to stress this relation took precedence over the conventions of our situation, and in this way confirms the part of the basis for my conjecture about the origins of the introspective Discourse model.

Further, we also gain insight into an important aspect of this Discourse model; namely that its function in Karl's case was a matter of avoiding harassment. Such a concern again points back to the issue of self-regulation, self-improvement and self-development at all costs but one: causing harm to others. He has to refuse the negative stereotyping, and the only way he can do that is by breaking the convention – becoming a 'confessing animal'. No matter what approach I took, he steered the conversation towards issues of himself. When I introduce the apparent paradox of 'the segregation of students that occurs when they choose different gymnasium programmes' and the alleged 'diversity of physics* students' he tells that he himself was more a 'nerd' than a leader.

Karl is not unfamiliar with the act of stereotyping; he just actively tries to avoid doing it. But it appears from the narrative constructions discussed here, that stereotyping is a part of his mode of conceptualizing the world anyway. In this way, the introspective Discourse model put a hindrance on my possibility of gaining insight into certain issues of students leaving, and at the same time it confirmed the existence of these issues and itself.

5.6 Summing up the chapter

In this chapter I present excerpts and narrative constructions of interview. In Section 5.2 I present exemplars of how the introspective mode is enacted by my interview participants in relation to explaining the reasoning that had led to their decisions of leaving physics*. In Section 5.3 I formed a conjecture based on Scandinavian research into expressions of contem-

porary social identity formation and, along with my own reasoning, suggest origins of the introspective Discourse model. In Section 5.5 I sought to establish the credibility of this conjecture by analysing a large part of a Discourse especially earmarked for this 'credibility check'. Here I found that in several cases that the Discourse in several cases pointing back to my conjecture. Thus I would argue that I have presented a credible basis for my conjecture and also for the interpretational lens that I draw on in my next chapter (Chapter 6 – Results).

6 Results

In this chapter I am presenting my results using a narrative method. How I have done this, and why I do it in the given format needs some further introduction and clarification. Connelly and Clandinin (1988) describe narrative as being a way of seeking and capturing rich contextually based meanings of actions as presented in, as for example, the kind of interviews that I did. Citing Eisner (1991) Mulholland and Wallace (1994, p. 237) further point out that the results of a narrative method has 'the self' as 'the instrument that engages the situation and makes sense of it in that the 'way we interpret what we see bears our own signature and provides individual insights [... and that] the knowledge to be explored and generated is the resource that lives in the biographies, thoughts and actions of individuals'. In this spirit what I have done is crafted a narrative using the interviews that I had with the participating students as my 'resource'. To enact, retain and emphasize the Discourse – the full richness of 'own story' – I have done this using the first-tense format. And although I often used parts of the participant's discourse verbatim my constructed narratives should not be seen as verbatim transcripts of the interviews, nor as just an interpretation of the discourse – language-descriptions – that constitute the transcripted interviews. My narratives are my constructions, constructions that are scholarly embedded in the spirit of Gee's (2005) big D Discourse in that my narrative constructions not only draw on the transcripts but also on my observations and interpretations at the time (hence also my post-interview notes) in order to include the other 'language in action' aspects captured in the interview interactions. What I mean by other aspects of 'language in action' is, in the words of Gee (2005, p.7) the transcribed language-descriptions together with the 'ways of acting, interacting, feeling, believing, valuing and using various objects, symbols, tools and technologies – to recognize [one]self and others as meaning and meaningful in certain ways' that formed an integral part of my interview interaction.

Now I will proceed to present my interview analysis. I will start out by analysing my interview with Marie, because her situation is rather different than the situations of the other interviewed students. Following that section I will present my analysis of the interviews with the remaining six students in terms of three themes: Aspects of socializing, The inherent ability to do physics*, and Students' own recommendations.

I will end each section by posing a general question that emerges from the preceding analysis.

6.1 Marie with a lens

Marie's story is somewhat different as, after being accepted into the physics* programme, joining the social initiation (the 'nollning'), and taking the preparatory course in mathematics that is given two weeks before the semester starts, she then changed to another programme at Uppsala University.

Even though Marie did not actually proceed and start studying the courses in the programme, I am presenting her story because I think it is a good place to start. A place that is starting with a part of the pre-physics* experience. This is because, as we shall see from the story, 'the culture of learning physics*' can actually turn students away from the programme even before they feel they have entered it.

To open my results section I use Marie's story to illustrate how I have used the 'big-D' introspective Discourse model (see Chapter 5) to analyse all of my interviews with the students and the kind of richness and additional insights that using the Discourse model brings to my analysis. I do this by presenting two analyses. The first is based upon the interview transcripts (in other words 'small-d' discourse) and the second based upon the Discourse of the interviews. I start by relating my first impressions in relation to getting Marie to join the interview because these impressions might be useful for the reader in decoding an own interpretation of the Discourse of the interview.

6.1.1 Getting Marie to join the interview

During my first phone-conversation with Marie I had to work very hard to persuade her to participate in the interview. But just at the point were I was considering giving up, she finally consented to do it. Not at my office, not at her place, but at a café somewhere in town.

I could understand her reluctance. When you are dealing with people that you perceive as imposing, you generally want to meet them in a place with 'a quick getaway'. Over the phone she told me that she did not really have anything to talk about, because she never actually started studying physics*. I told her it did not matter, because whatever experience she had, would be worthwhile listening to. So we agreed on a place and a time.

Two days before that time, she cancelled. Something had come up, and she would not be available until after Christmas (I had told her that because of deadlines I wanted to have my interviews completed before Christmas). So naturally I called her after Christmas, and she surprised me by agreeing to meet immediately – she wanted to get it out of the way as soon as possible. I rushed to meet her at a coffee-shop in the old quarter of Uppsala and realized that the place she had suggested would close half an hour later. And then she stood there.

She did not look angry at all. I had tried to summon all my good moods in order to be able to flash disarming grins at whatever defiant face I might meet. I met none. Just a petite girl radiating everything petite energetic people usually radiate: A bit of stress, a bit of haste, a lot of self-confidence and as she told me: a really tight schedule. I had just had the amazing luck of catching her on her day off. I guess I appeared less imposing in person, because when I pointed out the problem of the place closing before I thought our interview would be over, she invited me to her place, suggesting that we bring some pastries from the shop. As she started the coffee-brewer, explaining to me how she was still living in Uppsala while studying in Stockholm, I found my recorder, accepted the big comfortable chair and got ready to ask her why she had stopped studying physics*:

6.1.2 Narrative of Marie's story

Marie

I only briefly touched down in the physics programme. Really! I applied because I didn't know what else I wanted to do. I thought that it might be fun to be a meteorologist, but I also applied because I thought that it was such a narrow field or whatever, that I would be among the very few meteorologists in Sweden. It was kind of a way of cutting a corner. I wanted to be among the best, and I figured that if the competition wasn't that great, becoming one of the best would be easier. But then, on the prep-course in mathematics, I met four other girls who were also going to study meteorology. They had already been working with meteorology when they served in the military, and now, the military was sponsoring their education. It appeared to me that those four would come ahead of me no matter how I did, and then it didn't really seem worth the effort. What the effort was? Well, first of all it seemed like there was a full year of just mathematics. Not that I didn't like mathematics. I kind of like mathematics for it not having a strict purpose. Mathematics is kind of distanced and has a purpose of its own or in itself. Kind of like

playing a video-game. You might be spending hours getting a high-point score, which can be important in the game, but when you are done your score doesn't really matter. When you played you had the purpose of making the score – which was what drove you – but outside of that, the game, the point-score doesn't matter. It's kind of the same with mathematics. But eight hours a day, seven days a week for a full year. It just didn't seem worth the effort – knowing that I would come in fifth of us five, no matter what I did. So I changed to a three year engineering programme right when the semester started.

There the math was easier and so much more limited. But I didn't like the programme. Everything was so purpose-oriented. Like, everything we learned was put into immediate praxis in the lab. It was obvious that whatever we learned had some connection to something practical. And I didn't like that. I don't know. I mean, I chose physics in a way that can appear random. I just wanted to start studying, and then I wanted to study something that interested me. Not that I was interested in meteorology or physics especially. I think I was interested in the prestige and the money that comes with the natural sciences. I think you have to be especially smart to be good at science. That's also why I chose the engineering programme. It was in science too. But it just didn't have that part of the science that I liked. The part where it has its own purpose or whatever. I know that mathematics in the physics programme had that, it was just too much. And since my main purpose was prestige and money, and since that didn't seem like what I would get from becoming five of five in meteorology – I actually looked up the pay, and even if I got a job, the pay would be, like, seriously bad – I quit. I also quit the engineering programme to become a teacher instead. And I like that. I think I can become a really good teacher. It's not the same prestige-wise and so on, and that really gets to me. It bothers me, but then, I mean, I could become a headmaster of a school and get the prestige, but that would just take the fun out of being a teacher. And that would not be worth it.

Marie's story is at first glance pretty straightforward: She was admitted into the physics* programme because she wanted to become a meteorologist. She did the preparatory mathematics course offered before study-start, but decided that she did not want to study meteorology anyway. Instead she started on a three year engineering programme. She stopped that as well, and now she is studying to become a teacher.

As I mentioned in the beginning of this chapter, I now draw on the introspective Discourse model to illustrate how the model presents an analytic tool that extends the understanding of Marie's story. I begin this process by describing Marie's story as paradoxical.

6.1.3 Marie: a paradox

Even though the story presented in the previous section is so straightforward, I have serious difficulties making sense of the story. On the one hand Marie did not like the three year engineering programme that she switched to from physics*, because it was too purpose-oriented. But she switched away from physics*, because the very specific aspiration she had of becoming a prestigious meteorologist did not seem feasible. She had a specific purpose, but on the other hand, she was not prepared to do what it took to reach her goal or she thought that she was unable to reach her goal. At some point in our conversation she told me that if she actually had wanted to, she would have done it. When I said that I believed her to be competitive she responded that if she really was as competitive as I thought, she would not have given up. But as we could both see from her story, she did give up. On the other hand, at one point in our conversation we found out that 'it wasn't really a question of quitting physics, but of never starting'. She started studying physics* for the specific purpose of specializing in meteorology, but what she liked about the disciplines of physics and mathematics was that it appeared relatively unspecific and broad to her.

I find this to be a paradox: Specifically she wanted to become a meteorologist, but what she liked about science, was the joy of studying something just for the purpose of studying it.

6.1.4 Marie's story: focusing on issues of the introspective Discourse model

When Marie told her story, her main emphasis was on explaining to me that she never started studying physics*. But during this explanation I interrupted her stories by asking clarifying questions and discerning her 'ways of acting, interacting, feeling, believing, valuing and using various objects, symbols, tools and technologies'(Gee 2005, p.7) to allow recognition of her social identity.. Constructing Marie's narrative using the introspective Discourse model, I am able to show that the story she presents is actually covering issues of identity which are embedded largely in small 'side-steps'

where Marie Discourse-clarified issues for me. What follows is the richer story.

Marie

I chose the natural science gymnasium programme because I was really good at the science subjects. I don't think that the social studies programme would be that difficult either, but it's just like, if you know math, then you know math. So anyway, I was pretty good in gymnasium. I don't know, maybe if I had been at a better gymnasium I would have been more mediocre. There are all sorts of people in the physics programme, but they are all, like, brighter people. At the 3 year engineering programme people were generally older. They probably wanted to improve their life, get a quick degree and then earn some money. And there were a lot of girls there too. They were mostly my age. I did pretty good there, at the engineering programme. I got a five on my first exam, but then on the second, I got a four. That made me really angry, kind of. I dropped out of the engineering programme too, because it was too practice oriented. You knew why you learned everything, it all had a purpose and it seemed like the people there had a matching purpose. I didn't really know what I wanted to do, I just wanted to study at that time. I was kind of competitive back then, and if you don't know what you want to do, then it's kind of difficult to compete with the others. I mean, when I started at the physics prep-courses before study-start, I met four other girls who were going for meteorology too and were sponsored by the military. They already knew what meteorology was, and knew what they were competing for. I chose meteorology because I didn't think that anyone else would have thought of that. I wasn't interested in meteorology beforehand; I just figured that if I were one of the only ones in Sweden who had chosen to study meteorology, it would be a piece of cake to get a really cool job. Sure it would be hard work, but at least I would have been sure it was worth it. Having to compete with those girls made me stop being so sure about that.

What I liked about science was that it could just be there for itself, I mean, for its own sake. And since I just wanted to study for the sake of studying, I thought that science and my purpose was a good match: I was just there to study, and science is just there to be studied. But seeing that people were already ahead of me, both skill-wise and purpose-wise made me stop, and kind of drop-down to a less hard science programme. But there it was even worse in that way. It was just strictly through the curriculum with a definite purpose. I couldn't see that this was the case for physics, but people acted as if

> they could see the purpose of it all. That's why I changed, or never really started. Now I am studying to become a teacher, and I am sure I will be really good. I don't do that good though, but that is because I don't have to. I mean, I can sit at a seminar and just read the back of the book and the introduction and still pass. It just doesn't matter. No one expects anything of us. And even though I still don't feel devoted, no-one else is, so I don't have to worry about being last anymore.

It appears that her prior education convinced her of her own abilities, yet she did not blindly start studying at what she considered a prestigious programme. She chose a programme with a specific direction in which she thought she would be relatively unique. She knew that there was a chance that she would meet people who were brighter than her in the programme, but thought that she would not have to compete with them directly. She had envisaged a kind of pseudo-natural science that no one else perceived as such. She quickly realized that she would not be alone and also that the road to becoming a meteorologist was just as tough as every other road in science. The case was not that she was unwilling to walk that road; instead, the trouble was that now she had become really uncertain of where that road would actually lead.

Her first meeting with physics was the preparatory course in mathematics offered before study-start and she believed that experience to be an example of what was to come during the following year. She was not prepared to take up that fight blindly. She told me that if she had taken a course in meteorology directly after study-start she might have continued further into the education.

Marie's identity-project was centred on a preformed idea – the purpose of getting a prestigious job while exerting as little effort as possible. Marie is aware that even though her aspirations are personal, they are of a kind that will require her to pay attention to others' aspirations. Marie is trying to navigate in a knowledge-economy (cf. Chapter 5) in which she thinks she has found a niche for her identity-project. When Marie then met four other girls who were good at meteorology already, she realized that her niche was occupied, and she moved on.

If Marie's story was about a student who is unsure about the content and purpose of the studies that he or she is about to commence, it seems that such issues could be addressed by a changed course content. Besides offering courses that prepare students for courses to come, other more specialized courses could be offered that directly challenge preformed ideas about

the educational direction students have chosen. In this way the students can be offered a chance of facing and realizing their own confusion in a reflected way.

In Marie's case, such a course might have expanded her perception of the niche of meteorology, making her realize that she would not necessarily be in direct competition with those four girls, but that all five of them represent but a small fraction of all the meteorologists that are needed.

I am not saying that Marie would have continued her studies after an introductory course in meteorology, but such a course would have empowered Marie in a way that would make her capable of perceiving her situation realistically. Meeting the four other meteorology-girls was just one issue contributing to Marie's decision to leave, and to me, it seems like another was the structure of physics*.

Marie saw a logically constructed course-plan – focus on the mathematics that you need to take the physics that you need to take the meteorology (that you want). Such a course-plan requires students with a strong sense of purpose, especially if the goal has a specialization that is only realised in the final stage of the programme as it was in Marie's case (cf. Appendix 1). Marie quickly realized that she did not have that kind of 'sense of purpose'.

Even though Marie was not focused in relation to her choice of studies, she was still certain about her abilities. She just wanted to make sure that this certainty was not challenged (the reason she chose meteorology in the first place). In a strong sense this last part is explained by Case and Marshall's (2006) 'no-problem' Discourse model.

Marie was ready to work hard, if she was sure that the work would pay off in relation to a prestigious job. Since she was not sure about that, having met the other meteorology-girls, she did not want to work hard. Then she changed to another programme and did well for while. But when she experienced her first crisis 'induced by assessment events' (Case 2007, p 3), she realized that she did not like the strictly purpose-oriented way that courses were taught in this programme and changed again. In the new programme she is studying now, she is not doing that well; but she does not need to:

Marie	*I mean, you've heard about the Swedish teaching programme right?*
I	*hmmyeah... but*

Marie *But the quality of the studies, I mean that, is not that great. It's like... The pace is really low. They don't expect much of you. You can get by, by doing. I mean I went to so many seminars just reading the back of the book and read the introduction, and I could just talk my way out of it. Obviously I didn't get good grades but I could pass doing that. So I've had a lot of fun, like, doing other things and not studying during those semesters. But that was just ´cause, you didn't have to do more. No one expected you to do more.*

Even though Marie is not doing that well, she is still sure that she is going to become a really good teacher. Mostly, because she has shown that she can get through the programme with almost no effort – implied, that when she does make an effort it will be reflected in her results.

6.1.5 Summarizing discussion on 'Marie with a lens'

In terms of the question of what aspects of the 'culture of learning in physics*' that contributed to Marie's decision to leave, the answer appears to be:

- Meeting her future peers already during the preparatory mathematics course, Marie got the impression that unlike her, they had a clear view of where the educational programme would lead them.
- Reflecting on the course-programme and the academic years Marie had in front of her, this impression, that she needed a clear idea of direction, was strengthened.

I would like to end this section by posing the general question:

> To what degree is it reasonable to expect that students know what the programme is about and to where it leads before they start the programme?

6.2 Aspects of socialization

Having discussed the specifics of Marie's story, I will now focus on aspects common to the rest of the interviewed students. My methodological framework is primarily focused on 'learning as social participation'

(Wenger 2003, p. 4). Therefore it is natural that an important aspect of this chapter is the aspect of socialization in relation to having been a physics* student who decided to leave the programme.

The aspects that I focussed on in the interviews were aspects of socialization with respect to doing laboratory work and other group work in classes, but primarily socialization in relation to forming voluntary study groups. Here I would argue that the formation and active participation in informal study groups is central to understanding learning as participation in a community of student-practice vis-à-vis physics*. As I mentioned in Section 4.1.1.1, becoming a physicist is a gradual process of legitimate peripheral participation that over time leads to inclusion into a community of shared values and practice. One of these values must be, to value being a member of such a community, which is why I emphasized exploring the issue of voluntarily studying in informal groups. But as we shall see, the choice ramifications in relation to this sort of socialization far exceeds the boundaries of socialization in physics*.

I have found it useful for the purpose of clarification to divide this analysis into three sections dealing with the students according to crude stereotypes of their own perceived 'ability' in learning physics*.

In the first section 'The low achievers' I will focus on Susan, Anita and Joanna. In the second section 'The average achiever' I focus on aspects of Clas' story, while the third section 'The high achievers' concerns Thomas and Karl. Marie is not included because she did not actually start the study programme and I used her analysis as an exemplar of the fruitfulness of drawing on the introspective Discourse model.

6.2.1 The low achievers

In this section I am going to explore how the issue of socialization in relation to studying physics* is influenced by being 'the low achiever'. I will do so by presenting constructed narratives crafted from illustrative elements in the interview-Discourse from my interviews with Susan, Anita and Joanna respectively.

My impression of Susan when we talked was that she felt a bit insecure of herself. She did not take up much 'space' and it was difficult to encourage her to make long explanatory statements. However, she was very self-reflective and seemed to have a self-image that was founded in what she experienced as the reality of her personality, namely that she was not a social person. From the interview and the short answers she gave to my

questions I have composed a narrative for Susan in which she explains her experience and resistance to socialization in relation to studying physics*:

> Susan
>
> I was so bad at physics. I didn't pass that many exams so I had to leave. I think I was so bad at physics because I couldn't find a purpose to it. Maybe the difference between me and other people who have a hard time finding a purpose to the study is that other people find someone they can study with. I didn't. When I came to Uppsala I started studying together with two friends from my hometown, but they left physics before I did, so when they left I was alone.
>
> It seems that if you are not one of the geniuses to whom physics just comes naturally, you need to feel at home in physics in other ways. And friends would help that. It's not that people are unfriendly; it's just that they seem to be so much more outgoing than I am. I am really bad at meeting people and being around people I don't know.
>
> The others who study together also go to parties and to the pub and so on. It feels so stupid to say that in order to become a good physicist you have to drink, but it feels a bit like it is so. Maybe not drink, but to join them – and I would have liked to, but I just couldn't.
>
> It was at the 'lektioner' I learned, and here there was a possibility to do the assignments together. I also met people during the labs, but I didn't do very well in the labs, because there was nothing to look forward to. And sitting and writing the report afterwards, I really hated that. I mean, the labs themselves were long and exhausting, and then the report afterwards! So, in physics I don't feel like I can contribute with much when working together with others, so I didn't work with the people I met in the lab afterwards. I am not very social, I have learned that, so now I will rather stay at home or something, and not be reminded of that all the time. I don't want to be forced to interact with people I don't know in my spare-time. That is something that I have learned and something that made me not want to be there at all.

First of all it makes good sense that Susan feels that finding the purpose in learning physics* is something you have to do together with others (see Section 4.1.1.1) and she makes an interesting distinction in relation to be allowed *legitimate* peripheral participation: either you contribute by being proficient in physics* and/or you contribute by your social abilities. Since she did not feel that she could contribute with either, she did not feel that

she could participate. She stresses that people were nice, so the issue of being 'allowed' participation is probably an issue of her feeling whether it is appropriate to participate or not. One could argue that the issue of social and/or academic ability of contributing is not an issue intrinsic to the practice of physics* alone, but just a fundamental qualification necessary for all participation.

However, when Susan changed to a language programme, her experience changed:

> Susan
>
> The other programme I can do alone, and I don't make much friends either. But when we do work in groups, it is not an issue. I don't feel that I need to make friends with them. In this programme everyone is a beginner.

Susan declares that in the language programme she is now studying, all the students began at the same level, while in physics* the difference in people's ability was much more evident. If you are 'a genius' you do not have to look for meaning in cooperation with others. Furthermore, we can imagine that ability is not binary, but rather that there exists a kind of continuum of abilities. Following Susan's reasoning, this means that because people are so varied ability-wise, social abilities are brought even stronger into the practice of physics* then at 'her language programme, and come to play a larger role.

Because Susan uses the introspective Discourse model it is impossible to get closer to understanding the group-dynamics which are determined by social-skills through interviewing her. This is because, to her, the reason she did not become a legitimate peripheral participant of the physics* student community was because she was not 'good at that stuff' [social interaction] and not because they did not allow her to join. To gain further insight into such an issue, it would be useful to observe the students in their daily life. Hasse (2002b) has done such a study with Danish students, and I will refer to the results and conclusions in Section 3.4.3.

Whereas Susan was very hesitant socially, Anita was not. She loved the social aspects that followed in the wake of having enrolled in physics*:

> Anita:
>
> I don't regret having studied physics. It was one of the best times in my life. I was very social. I learned a lot of new stuff and got a bunch of new friends and so on. Our 'nollning'-group was one of the groups that became closest. Even though a lot of us study different

stuff now, we still meet and have parties together and so on. So it was quite amazing. I don't know why we got so close. We became really good friends and did stuff outside of that stuff that we were supposed to do.

Since we studied the same subject we also met and studied together, which the other groups didn't do. The other groups were just together because of the nollning. Instead, we saw it more as a possibility to get friends and get to know each other. We didn't study together much in the beginning, but as time went on, we did.

But as time went by, Anita also realized that she had problems in learning physics*, but:

Anita

The others didn't really have the same problems I had. A lot of them were smarter than me, but I also think that they were looking forward to studying more than I did. I don't think that I felt so good inside at that time – but that is something I have realized later. I wanted to do the fun stuff instead of the boring stuff – which was studying. So I could see that the other ones were studying. They tried to encourage me, but it didn't go so well. I did try to study, but since I think I started to study a bit too late, I couldn't see how I was going to improve myself.

The group Anita was in hit it off straight away, and slowly they used that relationship to support their study-activity. At the same time Anita realized that she was falling behind. I asked Anita why it was she did not react to the others' encouragements, but she could not quite explain why it was so, other than that she probably did not feel so good inside at the time. To understand more about Anita and her ways of socializing we will go back to her time in primary and secondary education:

Anita

In 'högstadiet' and in gymnasium I had a maximum of one or two friends from my class. The rest of them I found outside of class. For some reason I was always put in classes where the people had the only goal of studying and being the best. So there was not much socializing going on among us. Not that the others didn't have friends and so on. Absolutely, but I don't think that I had the need to be the best in class. I didn't see the point of studying so hard. I am not sure that the people in class hung out with each other for social purposes or because they wanted to study. But it was not that I felt that I was more social than they were. We were just different types I guess. The

> people I hung out with before gymnasium were apparently people from the other classes who didn't find any other group to belong to. It wasn't only geeks, but other people too. People who didn't find anything interesting about the others. So we kind of formed a group. In gymnasium it was a bit more open, but it was still people from different classes who formed a group. The rest of my classmates had their own social groups which I didn't feel that I belonged to. I think in gymnasium this sort of grouping was because we had so much confidence in ourselves that we didn't think of ourselves as outsiders. We were simply another group. Our group was more based on having the same interests, while the groups that formed among my classmates was more focused on having the same interests in studying the subject. So I went outside my interest for school and got friends in that way.

If we think of school as a place that facilitates social identity formation, Anita has for some reason decided not to mix 'business' and 'pleasure'. In gymnasiet it appears that she was of the impression that if she was to be with the people from her class, then she also needed to want to aspire towards being among the top-performing students in her class. Instead she found her friends based on other grounds. When she then enrolled at the university she compromised that principle, but soon, as 'business' started to require more room in her group's 'business'/'pleasure' arrangement, and she realized that her problems were of a different kind than the others, she did not feel so good inside. In terms of contributing to the group, she saw her position weakened by her lack of ability, so instead she removed herself completely from activities in the group that were related to studying: 'I wanted to do the fun stuff instead of the boring stuff.

If we are to view this chain of events from the insight we got from Susan's story, it is no wonder that Anita did not feel so good inside: She had always defined her social relationships in terms of what people have in common besides their academic abilities, and that had worked out fine for Anita. But at physics* social relations are also decided by academic ability, so her social position in the group was weakened without her understanding why. If we see this situation through the lens of the introspective Discourse model, Anita will have to point blame inwards – and over time, she unconsciously felt increasingly alienated from the group:, 'I don't think that I felt so good inside at that time. Though I didn't understand it before later.'

Joanna was not socially unsure of herself either. She was quite clear on her social position in relation to her peers:

Joanna

> I did not want to get to know them. I wanted to study at home and I did that, and that did not work, so I dropped out. I never got to know anyone.

As I have described in Section 5.2, Joanna tried to work at home and realized that it was not working out well. She fell behind and decided to switch to another programme. She also reported that a major problem for her was that she did not get up in the mornings to get to the physics* lectures in time, but that now that she is working she has to be on time, and so can do it. Therefore I asked her to contrast socializing in physics* with socializing in her workplace:

Joanna

> I don't know why, but I can be social when I work, but I am just introverted when I study. So there is a big difference between working and studying. I guess I have to be social when I work. At school it's not mandatory; I can choose to be myself. At work we have meetings all the time and I'm rarely alone in my work. I am the only one with my competencies and people rely on me. And that is satisfactory for me. In school, what is required is that I am writing papers and get good grades. And that is the satisfactory part of school.

Joanna wants to socialize on her own terms, but she can bend those terms if personal satisfaction follows. At work, personal satisfaction follows socialization, because it is a crucial aspect of being able to do the work she does. But at physics* the formal requirements are that you pass your examinations. How you do that is in principle up to you. Joanna feels strongly about that. At the same time she has discovered that in physics* the reality differs from the principle – which might make her resistant to socialization in physics*: 'I didn't want to get to know them'. She did not say 'didn't get to know them' and when I asked her what it was in particular that she did not want to get to know, she did not have an answer.

However this is not a psychological investigation into what makes Joanna do one thing or the other, instead, it is a search for meaning about what made Joanna leave. What made Joanna leave was that she wanted to study at home, and she came to realize that to be successful she had to be at university every day and discuss the problems with her classmates. She didn't want to accept that she would fall behind if she stayed home. But in this respect, she in a way has the same issue at work, and I had to ask myself (and her) what the difference was. The answer was, that the difference is that at work you have to socialize, and at physics* you are not, in principle,

required to socialize – but you do have to – even though you may not feel that you can contribute with anything.

This last statement applies to all three of the former physics* students who did not perceive themselves to be very capable in physics* – they did not feel that they could contribute to the group.

Now I will proceed with the 'intermediate' former physics* student Clas.

6.2.2 The average achiever

In this section I am going to explore how the issue of socialization in relation to studying physics* is influenced by being 'the average achiever'. I will do that by presenting constructed narratives crafted from illustrative elements in Clas' interview-Discourse.

I asked Clas how he studied and he reported that mostly he read alone in the breaks between lectures and during some evenings at home when he was not too exhausted. I asked him if he had joined a study group:

Clas

> Study Groups? I don't remember that there were any. Was that in the evening? But I sat together with some of the others to do hand-ins and such a couple of times. But that was not something that was organized or anything. That was just between us. But I think I studied with the others whenever we had time. That's naturally the easiest way of getting the stuff done.

As was the case with the 'low performers' Clas did not perceive study groups as something one would expect was a part of physics*. He is actually surprised that I am asking, because in his interview he is probably focused on aspects of the 'formal' physics* programme. That is also why, when I ask him about his strategy for studying, he does not mention the informal study groups that he took part in. To him, study groups were something separate from studying physics*, not an issue of legitimate peripheral participation. But now that he knows what I am looking for, he tells me:

Clas

> What I remember about the group work was that no-one really understood anything, so... Of course there were students who understood things real easy, and when they were there, then you could get some answers. But almost everybody who did the group work was at the same level as me. We could discuss and so, but at the end we just talked about something else.

As we see, study groups did not have an apparent function in learning physics* in terms of becoming more capable physics* students. Even though they could support each other in their knowledge that no-one could keep up with the pace, they could not contribute with anything more – except when the 'high performers' were around. So I asked him if there was any reason that he did not join up with them:

Clas *I have really no idea.* [XXX] *was one of the good students. And ehm... I don't know what they... I guess they studied together, so.. ehm... But I don't know.*

Clas was in physics* for a full year, and he attended almost everything that was on his schedule, but still he did not know what happened to the more capable students. But you cannot blame him for that: If study-groups are not legitimate participation, his impression would be that studying physics* meant going to all the calculation-classes and lectures, and his experience with collaborative work was that it did not provide anything except a speedy way of getting things done. And Clas did not just want to get things done. He wanted to understand them as well.

In summary, the students I talked to in the 'low' to 'average achieving' spectrum did not centre their efforts around studying with others either because they did not feel they could contribute with anything or because informal group work did not help with regards to understanding the course-work in physics*.

In the next section I will explore the experiences of the high achieving students.

6.2.3 The high achievers

In this section I am going to explore how the issue of socialization in relation to studying physics* is being influenced by being 'the high achiever'. I will do that by presenting constructed narratives crafted from illustrative elements in Karl and Thomas' interview-Discourses.

Aspects of Karl's story were explored extensively in Section 5.5 in order to establish the credibility of the conjecture about the origins of the introspective Discourse model. There I described how Karl primarily changed because he was more interested in another science. But as to the issue of socialization in relation to doing physics*, Karl's story can contribute even more:

Karl

> For me, during a normal week, I would usually go to school and then go home. I would seldom go to the calculation-classes, because I did other things. I sang in the choir, played football, played volleyball and was engaged in the nation-life. And since I did alright anyway, I didn't see the need to go to the classes also.
>
> It wasn't like I didn't socialize. I joined the nollning because it was really fun, and besides, compared to other university-studies you have lectures all the time so when you have a break it is nice to be able to go and talk to people. In that way you also find people that you can do old exam-sets with a couple of weeks before the exam. And that worked out fine. I could go to the lectures and read the book and then have time for all the other things I wanted to do. So I didn't feel a pressure to join in on more things. At some point we had a problem with a teacher, and people were walking around with lists of names, I'm not sure, but anyway we changed teachers after that, so that worked itself out, but I wasn't very interested in what happened with that part and I didn't really need to be either.

For Karl, studying physics* was usually a 'one-man-show'. During the days he studied physics* and during the afternoons and evenings he did other activities. When an examination was approaching he would meet with some of the people he had met during lunch-breaks and do some old examination-sets, pass the examination and then move on. When the students of his year had a problem with a teacher, they sorted it out, and he did not have to get involved.

When Karl talks about not feeling pressure to socialize, this should not be interpreted as a way of managing the socialization of a discipline such as physics*, but rather in terms of managing as a person in a community of practice. For people like Karl, to manage in the physics* student community it is sufficient to talk a bit during lunch – you do not even have to involve yourself in inter-student evaluations of lectures. Karl would have gone to the calculation-classes if he had found a need for it, but he would rather be doing something else.
In section 5.2 I presented a piece of Thomas' story in which he explained that he left physics* because he realized that his interest actually lay in mathematics. But Thomas started along with the other students who had chosen physics* and his input is valuable in relation to understanding what the 'high achievers' did instead of working in groups with the others.

Thomas

I had nothing of that. I signed up for 'fördjupningsspåret', and instead of the calculation-classes they offer extra lectures. But I don't know how much that gave me in the end. They were a bit above my level at the time, but it was interesting to listen to. I learned something and got something out of it. So I didn't have any calculation-classes that first year. The next year I took courses at a higher level than the others, and they usually don't offer that many classes in those courses.

In the interview Thomas tells me a rather complicated story about how he intended to study physics*, then found that mathematics was very interesting and started to take more courses than the formal course-plan dictates. But that did not go so well:

Thomas

Maybe I was just too self-confident. I thought I had an idea of what the course was about, and then instead of going to the lectures I just read the book. I did that while I took the mechanics course, because I knew that people did not think that mechanics was that terribly difficult. So at the end, I dropped mechanics completely and just concentrated on reading the extra math courses I wanted. I figured I could just do the retest in mechanics during the summer. But then I failed a mathematics course. I was a little bit shocked. During one of the previous mathematics courses I had been the best in class and I got a position as junior teacher. So even though I knew there was a possibility that I would fail when I did the exam, I didn't count on my results being as bad as they were. So I had to redo that exam during the summer and mechanics just got side-tracked in that way. I still think that I ought to take it – it's one of those things you should know about.

After that experience with the mathematics course that I failed, I realized that my strategy to do extra courses alone was wrong. I still knew that I wasn't incapable of doing mathematics, but I should go to the lectures and take the time it takes to actually understand the content instead of just taking the exams – doing things too fast. I realized that I should settle on doing the normal 20 points per semester, because during the first year I only got 36 points instead of the, I don't know, more than 40 points a year that I had intended with my original strategy.

What Thomas is describing is that when he started he signed up for the 'fördjupningsspår' which is a special course for those students who want

deeper insight into the content of the courses than is normally offered in the introductory courses. To find time for this deeper introduction, extra lectures are scheduled when the 'normal' students have their calculation-classes. In practice this meant that Thomas never got to experience the value that might exist in doing assignments together with other people. Rather, he got the impression that the 'high achievers' are high achievers because they skip the time-consuming aspects of sitting together with other students. Instead, he tried to spend this time taking extra courses on his own, by just reading the course-literature. He reported that his experience of the extra lectures offered in the 'fördjupningsspår' did not give him much, and must from that have inferred that what 'gave him much' (he was first in class in one of the early mathematics courses) was to study at home. So he continued to do that.

From the other students Thomas got the impression that the mechanics course was easy, so he put that on the side, for when he had some time during the summer. But then he failed in mathematics and chose to concentrate on that, rather than doing the mechanics as he had originally intended. His explanation for that is that he found that he was more interested in mathematics then physics. However, if his experience of an immediate reward for his work in mathematics (he was offered a job as a mathematics tutor) is weighed against his very limited experience in physics-courses, an explanation external to interest might also be offered.

Referring back to Figure 1.4 and Figure 1.5, a reason for Thomas' initial aspiration to study more than the required 20 points per semester is offered: Students who are successful learning in physics* do generally take more than 20 points each semester. So for you to define yourself as a successful student, it is necessary that you take more points than the recommended number. If we also take into consideration the 'fördjupningsspår' offered to the particularly interested (gifted?) students, the signal that is sent, is that such students do not need the calculation-classes, while the less 'interested' do.

This implies that the calculation-classes and consequent social interaction around addressing issues of studying physics* are something a certain kind of student needs, rather than something that all are required to do. Which in turn implies that the whole idea of physics*-related social intercourse needs to be removed from the students ideas of what legitimate peripheral participation entails: if the physicists' community of practice is the practice that the students peripherally participate in, then the most able physics* students must be the ones that have the best chance of realistically being admitted into this community of practice. In this sense the 'high achievers' are the ones that are most imbedded in legitimate peripheral participation

leading to admission into this community. Thus their behaviour will define legitimate peripheral participation – the right way of studying physics*. The 'average' achievers are also engaged in a legitimate peripheral participation, but that participation is a parallel to the 'high achievers'' practice.

I think that one way of distinguishing the two parallel participations is by the ease with which the two 'high achievers' see themselves imbedded in the participation, and the ease with which the two 'high achievers' explain their social engagement: We would have and could have engaged more if we wanted to – and as Karl states: *I didn't feel the pressure to...*

6.2.4 Summarizing discussion on 'aspects of socialization'

If we imagine that the six students whose stories I have used in this section were to form a study-group all (but Clas) could have been forced to give something that they did not want to give. Clas could have used Karl and Thomas' input, but then Karl would have had to give up singing in the choir, playing volleyball and/or his involvement in the nation. Thomas would have had to give up taking extra courses or taking classes for the 'especially interested'. Susan, Anita and Joanna could have used the input from Clas and his friends, but then they would have had to give of themselves socially to Clas, Thomas and Karl since they did not feel that they could contribute in relation to physics*.

On the other hand, many in the group could have gained a lot from the experience. Thomas could have given up a strategy that he eventually figured out himself was not going to be successful. Karl might have found that doing physics* was also about involvement in other people, Clas could have gotten some of the input he needed, and Susan, Anita and Joanna might have found that other people also struggle.

Put like this, it makes you wonder why such informal study groups are not perceived by these students to be a fundamental and integral part of learning for all in physics*.But Karl was able to study at home and still be able to find a network of students who were content just conversing with him over lunch, and only engaging in physics*-related practice a couple of weeks before the examination. Thus, these people must to some extent feel, like Karl, that this is the way you study physics*. Such a conjecture becomes more credible seen in the light of Thomas' story, where he tells that in the courses he chose, no calculation-classes were offered.

During the period that all the students who participated in my interviews studied, Supplemental Instruction was offered in physics* (both for physics

and mathematics courses). Supplemental Instruction is a scheduled optional initiative for students to engage in cooperative studies of the course-content helped along by a Supplemental Instruction leader whose role is not to be a teacher, but to be a 'learning peer'(Danielsson 2003). None of the students mentioned that they had heard of, or been engaged in, this initiative.

In terms of the question of what aspects of the 'culture of learning in physics*' contributed to these students' experience of learning physics* in a way that made them decide to leave, the answer appears to be:

- They needed collective learning to be a legitimate part of their perception of the student learning-practice.

I would like to end this section by posing the general question:

> To what extent does it serve a constructive purpose to have students, (a) divided between 'normal' and 'specially' interested, and (b) encouraged to take as many courses as possible over the shortest amount of time?

6.3 The inherent ability to do physics*

Another important aspect of several interviews was the issue of whether people have an inherent ability to do physics. Of the seven students I interviewed, four of them gave reasons for leaving that were directly related to their perceived ability in learning physics*. Of the rest, Marie felt that she was not a participant, and could not say anything about her abilities in practice; Thomas never had time to test his strengths against physics courses but felt that he was a talented mathematician, and Karl knew that he was 'good' at physics* but wanted to study something else.

Of the four (Susan, Anita, Joanna and Clas) who stated that they perceived their ability to be a problem in relation to studying physics*, all of them concluded that they were just not meant for physics*.

Joanna went a bit further, as we talked about her brother also having left his physics studies at another university. I asked Joanna if his choices had influenced hers, and she answered that they had not, and she continued:

Joanna: *Maybe we are not cut out for physics, my family.*

Thus it is hard to believe that her brother's leaving did not influence her. However, she could have concluded that she was not meant to study physics*, and as her brother was not meant to study physics either, it appeared to be a quality inherent to the family.

Clas on the other hand was a bit uncertain as to whether he was lacking an inherent ability or not:

Clas

> If you are interested in a subject, then you should just try it out. I don't feel that you can say that something is wrong with the education if it turns out that you can't manage it. Then you are just meant to do something else.
>
> If you study history for example, you don't come to a point where you realize that this is something you are not meant to study. If you study mathematics or physics this realization is quite obvious.

It appears that Clas felt that there was something definite about physics* that makes people realize if they can do it or not. From our conversation Clas expressed that this difference is that in History it is hard to come to an obviously wrong conclusion about something, while in mathematics and physics, you just have to look at the answer to see if you could do the calculation or not. But Clas is still a bit uncertain as to whether he himself was meant to study physics* or not:

Clas

> It's up to everyone to figure out if they are made for studying physics* themselves. But ok, if I had stayed in physics* maybe I would have figured out that I actually was meant for studying physics*. But at the same time, I didn't have time to understand the math and physics, so I am not meant to study at that pace.

Clas reported that he had heard from older students that the pace would slow down after the second year. But he had looked at the courses offered for second-year students and decided that it was probably in the third year that it would slow down. Finally, he also reflected that maybe 'things would just fall into place' as time went by, perhaps he just had not given physics* the time it needed.

It is extremely worrying that Clas perceived his need for finding understanding as a hindrance in relation to doing physics*. What Clas is expressing is an approach to learning physics* that in the literature is called a 'deep-approach to learning' (cf. Marton and Säljö 1976; Marton and Booth

1997) or a 'reflected approach to learning': 'reflective learning is the exploration of the object (the content) of learning through a mindfulness of the act of learning' (Linder and Marshall 2003, p. 280). Clas experienced a learning environment where his approach to learning made him question his ability learning physics*.

Situations like Clas' have been reported on in the literature (cf. Linder 1992) and they are not necessarily surprising. But I would like to point out that measures can be taken to avoid such a situation (cf. Chapter 2). As mentioned in the previous section, it would be desirable if students of 'all abilities' could be brought together and inspire each other in their learning endeavours. Susan, Anita and Joanna could definitely have used someone like Clas to meticulously address issues of physics* that he himself felt were hard to understand. As to the issue of struggling with a notion of inherent ability, Karl would have been useful to the rest:

Karl

> People who choose to study physics are usually good at mathematics, and people who are good in mathematics also believe in their ability in mathematics. People who start out doing poorly on the other hand, usually think that they can't do mathematics at all. But if they just tried and worked a little with it, they could probably do alright. So I think that being good in physics is something that you choose. You have to believe that you can do well, and if you believe that you can and want to do it, then you can. I don't think you have to be brilliantly smart to do well. It's just to compensate by working for it.

Karl said that doing well in learning physics* is to believe that you can do well, what Bandura (1994) has called self-efficacy. But to come to such insight requires realizing that ability learning physics* does not have to be inherent. But physics education tends to confirm the view that it is:

> The students learn from text-books whose interpretation of physics is not to be challenged; in fact it is not to be seen as interpretation. They learn to devalue past science because it is thought to provide no significant information about the current canon of physics, but they also learn from stories in their textbooks that there is a great gap between the heroes of science and their own limited capacities [...]
>
> (Traweek 1988, p. 75)

If the current way of presenting physics* only confirms the belief that physics ability needs to be inherent for success, then that belief needs to be challenged elsewhere. Such a place could be where students meet to informally work on physics* together. From the student interviews, it is my impression that physics* unintentionally hinders students' engagement in

such informal environments. I would like to quote from the textbook used in the first physics course in physics*. This is from the section entitled 'A Note for the Reader':

> [...] we have, at the beginning of the course, always written on the blackboard, as a kind of motto:
>
> ***At Home***
> ***by Your Desk.***
>
> Nearly all the chapters in the book are followed by a set of problems. [...] Most problems will demand some independent thinking. [...] We have good advice which has worked for many students: study the text, and in particular the examples, one, two, ... many times over. In the end, you will succeed.
> (Knudsen and Hjorth 2000, p. VII, lay-out as original)

The all encompassing focus, in this first recommendation to the new student, is on repeated effort that one engages in as an individual (at home, by your desk), and nothing else.

In terms of the question of what aspects of the 'culture of learning in physics*' contributed to these students' experience of physics* in a way that made them decide to leave, the answer appears to be:

- The belief that the ability needed for physics* as inherent is not actively discouraged.
- The culture of learning physics* is (unintentionally) an environment that confirms the belief that the ability needed for physics* is inherent.

I would like to end this section by posing the general question:

> Do we do enough to help the students understand that doing well in physics* is more about self-efficacy than about inherent so-called intelligence?[33]

[33]From the 2001 Physics Nobel Laureate Carl E. Wieman's autobiography: 'As one might imagine, going from the woods of Oregon to MIT was quite a culture shock. I did not do particularly well in classes my freshman year, [...] [and] I was not totally convinced when I started at MIT that I wanted to go into physics. [...] I never did terribly well in most normal courses [...], particularly ones that had exams [...]. I have had a pretty successful career in optics and atomic physics without having a course in either, for example. Some may argue that this could only work because I was an extraordinary student, and the more typical student must be required to take a formal curriculum with a large number of courses and exams. However, it might be noted that before obtaining this unusual "education" there was little to indicate that I was anything special as a physics student. So one could equally well argue that it was not me that

6.4 Students own recommendations

At the end of each interview I asked the participants if they had recommendations for how to improve the learning experience in physics*. I will present these constructed narratives here:

> Marie
>
> The main thing is to find motivation – to know what is waiting at the end. So I would say: 'Display what kind of jobs you can get afterwards.
>
> Anita
>
> Perhaps they could put some kind of distance-course on the internet. So that people can see if they are sufficiently prepared for starting physics*
>
> I did not understand my situation till it was too late. It would have been nice if there was a teacher who had noticed and sat me down and told me.
>
> Studying at university and receiving money from CSN more or less go hand-in-hand for the students. But the people working at the university do not have a clue about the rules that apply. You have to find that out by yourself, and you do not do that until you are already in trouble. So I think it would be good if the university made an effort to inform the student about the rules. Because they can be cruel sometimes.

These were recommendations that all seven students gave. At every other instance the introspective Discourse mode was 'in action'. I think that it is important for those who work with student evaluations to take the introspective Discourse model into consideration when conclusions are drawn from student evaluations. As an example, a recent interview-study of 20 students who left four different programmes at Uppsala University (Appel 2007) lead to the following conclusions in relation to 'prevent, understand and hinder' student attrition:

- Students need realistic expectations in regards to what studying at the university involves, and what the future after graduation entails.

---

was exceptional, but rather the education I received. Perhaps if far more students learned physics in the haphazard way that I did, many more of them might turn out as motivated and successful as I have been.' (http://nobelprize.org/nobel_prizes/physics/laureates/2001/wieman-autobio.html, accessed 7 June 2007)

- During the studies, it is important that the university encourages contact between student and industry.
- The university will have to better support students that experience crisis in their studies.
- A larger variation in the way examinations are given would improve student motivation.
- The demands on students, both formal demands but also in terms of learning-outcome need to be clear.

Generally clarity and purpose are called for from the students that Appel (2007) interviewed. I imagine that these are needed in order for the students to be able to adjust their identity-project to the demands that are posed on them when they choose to study.

I would like to end this section by posing the general question:

> Do students voice their problems in relation to studying in a way that can allow fundamental conclusions to be drawn from evaluations that take the students' voiced issues at face-value?

7 Conclusion and discussion

In this chapter the threads that have been woven throughout the thesis are drawn together, starting with a reminder of my research question:

> When students prematurely leave the physics* programme at a well-established research university in Sweden, what aspects of the culture of learning associated with that physics programme are related to their decision to leave?

The answers that I have found in relation to this question will appear in a short and concise form in two sections named conclusion. These conclusions are separately followed by sections of discussion. Following these two, is a section of general discussion.

However, I must first elaborate on an issue important to these conclusions – the issue of generalizability, that is, whether these conclusions are applicable to more than the seven students interviewed. These students were not chosen to be a representative sample of all the students who have left physics*, nor is seven a very large number of students to investigate. Yet I would still like to argue that the results of this study are more widely applicable.

Each conclusion that I state are drawn from my seven interviews with students who had left studying physics* before they graduated during the period 2000 to 2005. These conclusions are deeply imbedded in my qualitative research strategies. Results from qualitative research are not directed as being predictive but at generating understanding. This means that results from a qualitative research inquiry like mine should not be expected to be generalizable in the traditional quantitative sense. Rather the results should be presented in such a way that they facilitate being transferred to different contexts via a process known as naturalistic generalization (Stake and Trumbull 1982). Naturalistic generalization is about recognizing things in such a way that it brings new understanding to a different setting. To open the way for such recognition I have attempted to provide as much comprehensive details as I can about all aspects of my study. In other words providing what is known as a thick description to draw out questions of own practice and own ways of knowing (cf. Lincoln and Guba1985; Clandinin 1992). A good analogy for enabling transferability

via the provision of a thick description can be found in the value readers give autobiographies when they find such texts to shed new light onto their own lives (Danielsson 2007).

In this spirit, I have stated each conclusion in a way that assumes the results from my seven interviews with students who had left studying physics* before they graduated to be more representative than just for the students who participated in my study. This is of course cannot be taken for granted. Only my tick description can enable such naturalistic generalization, which I trust it will for many interested readers as they take in the landscape of physics* and physics*-like education through a new set of lenses, that my work hopefully provides.

7.1 Conclusion: The numbers

For this conclusion I repeat the discussion at the end of Section 1.1.5:

In Table 1 I draw out the 'key numbers' from my data-collection as on overview of the quantitative results that I obtained:

	Total	**Men**	**Women**
Students starting physics*, 1997-2002	166	111 (67%)	55 (33%)
Students leaving physics* (attrition rate)	95 (57%)	61 (55%)	34 (62%)
Students leaving physics* *and* Uppsala University	49 (30%)	33 (30%)	16 (29%)

Table 1: Key numbers from my quantitative analysis. The percentages are calculated relative to the category of specific relevance (for instance, the female fraction of 'Students leaving physics* and Uppsala University' is calculated in relation to the female fraction of 'Students starting physics*').

I believe the most noteworthy aspect to draw attention to in Table 1 is the difference in the fraction of men and women who leave physics* compared to the fraction of men and women who leave Uppsala University altogether. Note, that physics* is an experience for students that 'turns them off' studies at Uppsala University in equal proportion across men and women, *yet* they also tell us that physics* is an experience that 'turns off' relatively more women than men studying physics*.

7.2 Conclusion: The introspective Discourse model

Students evoke an introspective' Discourse mode when they voice problems in relation to the culture of learning associated with physics*. That is, if students perceive that they have problems in relation to physics* they interpret those problems in terms of their own perceived abilities and social identities.

7.2.1 Discussion: The introspective Discourse model

Arguably this conclusion does not on an apparent level answer my research question, because this conclusion tells us what it was in the 'culture' of the student that contributed to his or her decision of leaving physics*. However, one must keep in mind that the reason that the introspective Discourse model is enacted lies in its inverse relation to physics*: If it is accepted that students resort to explaining their troubles in terms of an 'inner' lack of ability, in terms of self-efficacy, then this acceptance is an aspect of the culture of learning associated with physics*. Since students *do* resort to this Discourse mode when they explain to themselves and the embodiments of the culture of learning associated with physics* (e.g. peers, teachers and me) why they left, the mere identification of the introspective Discourse model also identifies the culture in which it makes sense. In this case, the culture of learning associated with physics*

The students appear to have an impression of the environment as something monumental, something that one either has to 'reject or accept'.

In this sense there are two aspects of the introspective Discourse model, one being in terms of self-efficacy and the other in terms of 'letting life happen to you'. Some students wake up one morning, and find that they are not studying physics* anymore. Making sense of this is not problematic by virtue of the 'it just happens that way' part of the introspective Discourse model. For those who found that they were not doing well in physics*, the 'not being good enough' part of the introspective' Discourse model in respect to self-efficacy becomes predominant in student Discourse.

Accepting students to engage in an introspective Discourse mode in practical dealing with every-day life in physics* conversely embodies the culture of physics* as something that can either 'reject or accept' the students.

The students that in particular are accepted and especially accommodated are the 'specially interested' or 'talented'. Such students are encouraged to

undertake a practice different from the 'normally interested' students, by that setting an example for those. This leads me to the next conclusion:

7.3 Conclusion: Group work is not a legitimate practice

Informal groupings to collectively engage in the learning of physics* is not considered an integral nor natural part of the learning culture associated with physics*. (I have argued that such group work should be made natural and legitimate.)

A simplified model of three student stereotypes illustrates how group work is not imbedded in the legitimate practice as it is now:

1: The struggling student does not wish to actively seek participation in informal group work because they does not feel that they have anything to contribute in terms of physics* related ability.

2: The normal student does not actively seek participation in informal group work that is engaged in seeking a deep understanding of physics*. This is because it is viewed as being non-productive. No one in the group can contribute anything towards the goal, other than confirming that deep understanding cannot be reached within a reasonable time-frame (i.e. before the examinations).

3: The talented student does not actively seek participation in informal group work because they feel that, as talented students, they do not need to. This 'independence' is part of the social identity of the talented student – if a student needed to rely on others, then they would be unable to stake out a social identity as a talented student.

7.3.1 Discussion: Group work is not a legitimate practice

7.3.1.1 Students do work in informal groups

When I walk down the hallways of the building that holds physics* these two conclusions appear to be in stark contrast to reality. There are students sitting everywhere engaged in informal collective work. However, these are not the students who have left. These are the students who have been able to find meaning in their choice of studying physics*. They each have an individual identity project that they are pursuing and each of them has found a way to both accommodate and have their social identity accommodated.

7.3.1.2 What informal group work could cultivate

Suppose that informal group work was considered to be part of the legitimate peripheral participation of being a physics* student. I would like to postulate what changes that could make in physics*. First of all, there is a strength of the introspective Discourse mode, namely that students are each and every one 'specially interested' in listening and paying attention to their own needs. Thus, if a central part of the legitimate peripheral practice was working in informal groups, then students would get together and work, and they would figure out a way to accommodate their personal attributes as learners to the environment. The 'talented' student would apply their talents in relation to these collectivist engagements, the 'struggling' students would learn that 'struggling' students are a majority and the students together would realize that there is no 'normal' physics* student. They would find that engaging in a deep approach to learning is a constructive way of functioning for students of all abilities and talents. However, there is a danger that the students will find that they do not have the time it takes to both get through a packed curriculum and also engage in a deep approach to learning. Suppose the practice of working in groups was made a legitimate and even required part of attaining the competencies that characterizes a successful person in a knowledge-economy. This could facilitate opening the possibility for students to move beyond using the introspective Discourse, and encourage them to start openly addressing what problems they might have, in a way that allows teachers and policy-makers to constructively attend to the issues. As long as the students leaving 'blame themselves', no understand will emerge beyond that there is something wrong with the students.

7.3.1.3 Recommendations for encouraging group work

The solution I suggest is to start out by getting the students to discuss their issues among themselves in a metacognitive way (in other words, in a way that helps them come to know themselves as learners and to thus be in control of their learning). It might not be necessary to restructure the whole programme to accommodate group work, but a start could be a slight shift in attitude. This might be initiated by telling the students on the opening day of the mechanics course that the first thing they have to learn is that part of 'A Note for the Reader' in Knudsen and Hjorth (2000) is pedagogically unsound: problems in physics* should not be addressed alone, at home, during the night, under a 40W desolate desk-light. Problems of physics* should be addressed openly, in the lecture and in small informal groups.

7.3.2 The goals of undergraduate education

I would like to end this chapter with a final general question by referring to the five 'overarching goals of undergraduate education' given by Uppsala University, viz:

1. that it shall offer students quality, research-based instruction, availing itself of the advantages of a complete university, with ample opportunity to attain learning, broadened perspectives, and personal development;
2. that it shall offer competitive professional programs and other preparation for professional careers so that Uppsala graduates will be in great demand on the labour market both nationally and internationally;
3. that it shall be of such high quality that the University will be an attractive partner for student exchange with the best universities in the world;
4. that it shall be designed to enable students to complete their education within the given time frame;
5. that it shall be geared to entice individuals to return to the University for studies and self-improvement later in life.

How can the insights provided by this study inform the better generation of these goals?

Future Research

I don't think I was meant to study physics*. I thought so then, but I don't anymore.

It would have been extremely informative to have talked to this student while she still thought she was 'meant to study physics*', and have talked to her again as she started to realize that 'maybe she was not meant to study physics*'. Furthermore, it would be analytically productive to get to know the other people that this student interacted with and to investigate their related learning experiences, particularly as it relates to informal group work.

I have illustrated that informal group work is not always perceived as being part of the legitimate peripheral participation of studying physics* and I then argued that it should be.

It would be interesting to continue this research path with an ethnographic inquiry into the formation of informal groups working together on learning physics*, that is, how groups working with learning physics* could spontaneously arise and how that spontaneity could be culturally acknowledged by teachers and students alike. Since it would be impossible to follow all the students during all their working hours, for such a study I would ask the students who enrol in physics* to keep a diary of why and who they informally learn with and to reflect on their experiences in connection with this learning. I would ask participating students to also join in 0n regular 'informal' discussions about their daily experience in physics*. Such a longitudinal approach would be able to capture further fruitful insights, which could meaningfully further inform the transformation of the learning experience of physics*.

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Appendix 1: Overview of students

Here I will give an overview of the students I interviewed for this thesis. The students had all studied physics* at some point between the period 1999 and 2004. Physics* is one direction within the natural science programme that was offered at Uppsala University between 1989 and 2006. It was a four year programme within science with the aim to give a Magister exam in a specific subject. After 2006 a new programme has been introduced to meet the requirements of European educational standards.

During the first two semesters the physics* students mainly take mathematics courses and an introductory computer science course, in parallel with students aiming for a mathematics or a computer science degree. The first year of the physics* programme is concluded with an introductory mechanics course. The second year consists of basic physics courses, such as thermodynamics and electromagnetism. This provides a foundation for the students to specialize in different areas of physics.

The last two years of the programme provides many possibilities for specializations. The students can choose from many different courses. Some of the directions students can choose to specialize in are astronomy, meteorology, theoretical physics and materials science.

Overview of the Narratives

To attain insight into the highly complex problem of student attrition highlighted in Chapter 1, I have performed a set of interviews with seven students who had previously studied physics*, but had left before graduating. These seven participants were selected from seven criteria: if they had left the university, just physics* or were still studying physics*; if they lived in Uppsala; how much coursework they had done in physics*, their sex, their age, when they started physics*, and if they were willing to participate in the interview. These interviews were later treated and sought reproduced through themed narratives subsequently analysed. These narratives arose from seven semi-structured interviews, where participants contribute by representing a variety of different stories about leaving.

Underneath I have given a set of basic characteristics of the students. This set is limited to pseudonym, gender, year of enrolment, their status (in terms of leaver or changer), the number of credit points attained in physics*, their time in the physics programme and finally their age when they participated in the interviews:

Pseudonym	Sex	Start	Status	Points	Retention	Age at interview
Susan	F	2004	Changer	34	1½ years	22
Anita	F	2002	Changer	12	1 year	24
Joanna	F	2001	Changer	0	½ year	28
Clas	M	2000	Leaver	35	1 year	30
Marie	F	2002	Changer	0	0 years	26
Thomas	M	1999	Changer	35	1 year	27
Karl	M	2003	Changer	45	1 year	26

The time and place of the interviews was as follows:

- Susan: 22nd of November 2006, in my office
- Anita: 5th of December 2006, in my office
- Joanna: 13th of December 2006, in my office
- Clas: 10th of January 2007, in our conference room
- Marie: 10th of January 2007, in her home
- Thomas: 18th of January 2007, in our conference room
- Karl: 22nd of January 2007, in our conference room

In the following seven sections I will give a short account of aspects of the stories that each of the participants told me. The aspects I have chosen are meant to introduce the participants to the reader with the intention of opening an enticing window to my engagement with the interviews in the main parts of the thesis.

Susan

When Susan started studying physics*, she expected to meet a study best described by challenging philosophical consideration about the world and its workings. This was not what she met and she quickly lost motivation. This loss of motivation brought with it an inability to find or search for understanding of the cross-purposes of any of the courses suggested in the physics* programme, reinforcing her motivational lack. Consequently her studies offered no purpose, and since she defines herself as a shy person having problems initiating and sustaining loose social relations she was quickly left alone in finding purpose with the studies. When she enrolled

in the physics*, she did it along with old gymnasium friends who offered her both disciplinary and personal support, but as they left early during the first semester she was alone and incapable of finding other students that could help her along with the everyday struggle in trying to learn physics* and finding purpose. Susan changed to studying a language study at Uppsala University, where she does not find herself dependent on help from others.

Anita

Initiated by an early interest in astronomy Anita decided in gymnasium that she wanted to study meteorology, spurred on by a project she did on volcanoes and tornadoes. She went to ask her career advisor how such studies could be brought along. The career advisor did not have a clue, and had to phone around, because no other student had previously wanted to study meteorology. Anita cannot remember ever having had physics in gymnasium, but knows that she must have had. All in all she felt in retrospect that she was severely under-prepared for science-studies at university level.

In both högstadiet and the gymnasium she had a complex social life, defined by a strict and to some extent conscious division between disciplinary dealings and social intercourse: she did not have her classmates as her friends.

During the first semester of studies Anita had a feeling of not having a clue about what she had in front of her. She mentions not being allowed to use calculators as a significant surprise, underlining her actual epistemological confusion: she thought that dealing with mathematics at the university would be the actual same as dealing with mathematical exercises in gymnasium. She spent her first year actively trying to change her approach to understanding mathematics, but did not feel that she did well. In the beginning of the second term she understood that her basic understanding of mathematics was insufficient, and that before she could proceed with her coursework she would have to redo the whole first semester. The friends she found during the nollning tried to help her, but she resisted their attempts because she did not want to mix 'business with pleasure'. Her studies were characterized by being frustrating and almost hopeless, while she very much appreciated and enjoyed the social opportunities that came with the nollning. After one year in physics* she left, because she felt that she had understood that she was not meant for studying physics*.

Now Anita is studying languages at Uppsala University.

Joanna

After the gymnasium Joanna spent three years studying in the humanities at Uppsala University and did some travelling in that relation – all to 'broaden her horizon' before she intended to start serious studies with a professional aim. She enrolled in physics* because of a lifelong interest in astronomy and believing that philosophy and physics had a lot in common. Joanna expected to meet a theoretical challenge that would keep her at home pondering. Instead she found that in order to be able to pass, it seemed like she constantly had to engage in group activities with the other students. The schedule being organized in a way that suggested to her that she had to be in school from 8 to 5 every day, constantly having to engage in activities with the other students became overwhelming for her. She felt she already had a social life that she did not want to expand. But when she stayed home she did not work because of the way she understood the studies to be structured as participation in labs, classes and lectures and fell behind.

During her first half year in physics Joanna gradually changed from spending her time studying to working at a nation until she finally worked full time. Later Joanna started taking courses in the humanities and got a degree at the end.

Clas

Clas chose the vocational gymnasium programme and subsequently started working. After six years he was finally forced to do his military service, but when he finished he did not want to return to the 'working life'. He was tired of the business overall, and since he remembered liking mathematics from gymnasium he wanted to pursue that interest. He did the teknisk basår and applied for joining a physics programme at a högskola in Stockholm – just to try it out. But since he did not manage to find a place to live, and since his brother had an apartment in Uppsala, he decided to start studying physics* instead.

Clas' experience of the studies was that there was extremely much to do. The schedule was full from seven in the morning till five in the afternoon, and he never got time to let what he had learned sink in. Within his first year he passed courses equivalent of 35 points, but he was not satisfied with his outcome of the courses he had taken. To him it felt like he had the choice of passing the examination or trying to understand the subject matter, and consequently fail the examination because he was too slow compared to the curricular pace. Occasionally Clas studied with friends from his class, but he did not feel that they could gain much from each

other. The people he felt affinity towards and naturally worked with were all at his level, and all were stressed or frustrated by the pace.

After the first year Clas decided he needed a break. During the summer he worked, and found a job that he liked. He never decided to stop studying, but when he got children he realized that he would never return to physics*. Clas has decided that when he finds a bit of time, he is going to take mathematics courses one by one, and let it all sink in, in its own time – just for his own sake.

Marie

Marie is somewhat different from the others, in that she claims to never have been studying physics*. She applied for the physics*, joined the nollning and the mathematics preparatory course. But the prep-course scared her away because she got a taste of what awaited her a whole year ahead. Marie wanted to study meteorology and accepted that mathematics might be a prerequisite, but could not accept that she would have to do mathematics every day from eight to five for a full year. Marie had started studying because she thought she had found an interesting niche in meteorology that not a lot of other people had considered. She thought that she could occupy this niche as one of the top practitioners in that not much competition would be offered. Instead she met four other girls during these first weeks who already had meteorological experience from the military, and who actually received their pay from the military. In effect Marie felt that she was behind from day one – she did not even feel she had the motivation to get through the first year before she could test her talents against the field of her choice. Besides, these girls were prettier than she was, and could easily get a job as weather-girls before she would ever be offered that job.

Marie changed to a three year engineering programme at Uppsala University because there was an open spot, and because she still wanted to have what she considers a prestigious education in natural science. There she found everything being too application-oriented, and not at all in accordance with the abstractness of science that had originally attracted her.

Marie went out looking for other open positions at universities and found an open spot at a teacher programme. She regrets the loss of prestige, but believes that she will become an outstanding teacher instead.

Thomas

Thomas started studying physics* with the intention of working with theoretical physics, and being confident in his mathematical skills he signed up for the fördjupningsspår where the tutorials are substituted for extra lectures. He realized later that this decision had been a mistake, in that the level was slightly too high for him. When he approached the summer he had to drop one course in order to be able to focus his attention on the remaining. He chose to drop the physics course. During the summer he tried to make up for the loss of points by independently studying for a mathematics examination scheduled late summer. Thomas failed the examination and was surprised by his extremely low score, and decided for the future that independent studies was not an option any longer. So, at the third term he chose not to take another physics course, on the one hand figuring that since he had missed the first physics course more advanced courses might be tricky, and on the other hand that the mathematics courses offered that semester looked more interesting. One thing led to another and slowly Thomas realized that he had left physics. At no point was he seriously given or considering doing the tutorials available.

Today Thomas is doing his PhD studies in a natural science field. He has considered taking more physics courses at several occasions, but there has always been something else more appealing.

Karl

After the gymnasium Karl spent one and a half year in three different folkhögskolor. Karl then enrolled at Uppsala University spending another one and a half year with fristående courses in the humanities before finally commencing his physics* studies. Karl's family on his mother's side has a strong academic history in the natural sciences; his great-grandfather and grandfather both occupied prestigious positions as engineers. At that time Karl did not distinguish between physics and engineering, and he always thought of physics as his ultimate career-path. But since he had some financial support from home, Karl was never in a hurry to get a degree and could allow himself to get a taste of the other academic disciplines available.

Karl studied physics for one year, was on track and received good grades, but chose to take a break from the physics* that he felt was 'too distant from the world' and engage in social studies for a while. During those studies he heard of a certain discipline in social science and decided to continue in that direction.

Karl experienced the physics* studies as being easier than the previous studies he had done in the humanities. Most notably, he felt that the workload was less in physics*. When he studied, he attended the lectures, and approaching an examination he read the book and met up with people he had met during his lunch-breaks to do some old examinations a few days before the examination.

Appendix 2: My interview protocol

Interview Protocol – 3rd edition [5th of December 2006]

1. **Introduction**

   Recording: I am going to record this meeting, and it is just for me to avoid having to do notes while we talk. I hope you are ok with that.

   - Presentation of the study: I am trying to figure out how students have to change in order to be able to get a degree in physics.

     Goal: I hope to be able to shed some light on the reasons why 50% of the starting students stop studying physics here at Uppsala.

   - Interview protocol: We are basically going to have a conversation. I have a list of themes that I would like us to touch down on, but they are not strict, and the conversation might go in other directions. The subjects that I have chosen are about:
     - Your background.
     - Your experiences with physics.
     - Your decision of leaving.

   - Personal subjects: There might be a chance that my questions can be too personal for you:
     - But if you feel uncomfortable, just say so and we will change the subject or turn of the recorder if that would make it better.
     - This way of doing research is really, really common. Most researchers in my field will have done it at some point, and I have also done it before. Without people like you, this would not be possible, so I am really grateful that you are here!
     - I view you as an expert on the subject. This means that nothing you can say is wrong..

.

2. Themes that can be discussed:

Background.
Place of birth, parents and their expectations, living.
School and interests.

Choice of starting.
Why choosing physics, alternatives, plan for life (money, prestige, sense-making).
Why choose Uppsala, other alternatives.

Experiences in studying.
Settling down, friends in- and outside study, involvement in social activities – study, nation, other.

Strategy for learning.
Choice of courses, reasons for choices, attendance.
In lectures (föreläsning), laborations, tutorials (lektionar), working in groups.
Support from peers, family/friends, teachers, University (institution/'the system')
What does it take to learn physics?

Changing as a person.
How to fit in, being yourself / being a student.

Reasons for Other People.
Staying, leaving, doing well, not doing well.
Supporting others or not, receiving support.
Doing well socially, with the teachers.

Decision of leaving [only in interviews with leavers].
Circumstances, alternative decisions, time and process of decision.
Reactions from family/friends, peers, teachers, institution.

The archetypical physicist.
Other people, you, reality, the archetypical student.
Claims of knowledge and truth.

Suggestions for the institution.

Do you have suggestions for other people that I should talk to?

Appendix 3: Transcript for comparison with Section 5.5

On the following pages I will bring an excerpt of the transcript of my interview with Karl. This transcript represents approximately the middle-half of the entire interview – the part that was treated in Section 5.5.

I have tried to approach the feeling of the ongoing co-construction of the conversation, by adding comments as they fell during the conversation. Often you give each other encouragement by saying 'mhm', 'yes' and so forth, as well as you for instance can show disagreement with what somebody is saying by 'no' or a 'ehm' while the other person is talking. At other times you finish each others sentences or interrupt. So, a block of text/transcript starting with a capital letter indicates that sufficient time has passed to actually consider this a new statement, while a block of transcript starting with a lower-case letter indicates that the sentence is initiated right after the other person has stopped talking – as would be expected in a normal conversation. The three dots in a row indicate a pause in speech. If more than one set of three dots follow each other it indicates and even longer pause equivalent of maybe half a second for each set. If speech is interrupted or both the participant and I are speaking at the same time, it is indicated by the text in the next line either continuing at the same vertical position as the previous text stops (vertical position could be the equivalent of the x-coordinate in a x/y coordinate system, y being reserved for indicating shift between speakers, while x indicates the ongoing speech, or time if you want.), or just being added under the words that are spoken at the same time. I have done the appropriate shifting of lines and interruption in order to allow the only exception to that rule being at the start of each text/transcript section, indicating shift of speaker. Interruptions and simultaneous speech does only occur in the interview when the print is displaced towards the right. Words that end with a dash indicates a half pronounced word when I have not been able to make it obvious by just ending the word, for instance, only pronouncing 'Upp' in 'Uppsala' does not need a dash, while only pronouncing 'whe' in 'whether' needs a dash to not cause confusion. Finally explanations to the text are added in the very few cases it is necessary.

I no… How did you study? I mean what would a normal day look like for you, or a normal week?

2: A normal week, when there wasn't an exam coming I would usually go to school, and then I would go home…

I Ok, what would you? You would participate in all the lectures?

Karl yeah

I and the calculation classes or the

Karl noo not often.

I Why not?

Karl I don- I did other things. I mean I sang in the choir, played football, played volleyball, was engaged in nationslivet. And I did alright anyway, so… I didn't take.

I yeah? A lot of people I've talked to have talked about physics as 8 to 5 job every day.

Karl ok?

I Ah, you didn't experience that at all?

Karl No. I studied to the exam the week before, perhaps a little more. I read a book, and then I did some exams. Ehm, and then I went here the last days and talked to some with [inaudible word] did a few exams with some of my class mates. Yeah

I ok, the day, or a couple of days before, you did some old exams with your classmates?

Karl yeah

I Where did you find those classmates, I mean if you didn't

Karl During my lunches and breaks, I mean we were here, I mean when you study physics, it's true you start sometime, I mean you spend a lot of time in school, if you compare with many other courses at university. You, I mean you have three courses running at the same time, so you have a lecture in analysis at the morning, and then you go and eat, and then you have another lecture in

I mechanics

Karl calculus or something. Yeah. Or mechanics or anything later on. So you have lots of time talking to your classmates. So that wasn't a problem.

I ok, but I mean, ehm, you are probably a 100 persons in one of those lectures

Karl Yeah, but I mean you always find someone to talk to, during.. I'm not sure how that works, but it always does. I mean. So

I yeah,yeah

Karl Yeah, we had this introduction thing as well. At a program

I Nollning?

Karl .Nollning

yeah, so that helps probably

I you joined that?

Karl Yeah, I participated.

I What did you think about it?

Karl It was nice... I think... Yeah I think it was good. A good thing.

I Yeah, because I'm a bit uncertain on what people think about that actually. Because when, I mean if you come directly from gymnasium to a new city where you don't know anybody then it's a good way to socialize. I guess you do a lot of stuff together. Games, parties and so on.

Karl yeah

I But then, if you are already settled, and you have been to university for a while, then it, I would at least think it would be ridiculous if I were to join it now, for instance.

Karl Yeah, but you are a bit older than.. I mean I was still twenty.. twenty-something, twenty-one-two. So I wasn't much older than the rest of them. So I.. And.. I mean still it's a new, the new class that you meet. And you have to meet them somewhere, so. And it was, its still. There is nice, we did pretty fun things I think. Back then. You still have to socialize even if you know people in the town. It's nice to, hang out with people. I didn't participate in absolutely everything. I thought, because I lived already, I had for example the choir, and some classmates from earlier on. So, other people. So I didn't participate in absolutely everything. I didn't feel the pressure to... be in all the parties, in every... every game.. But some.

I ok, but that was a good way for you to like get a base of knowing people?

Karl Yeah, so yeah, when you had a break you could go talk to people. And there always group up some people and you talk to other people and pff.

I exactly. Alright, and why did you switch?

Karl From physics?

I mhm. Was that a

Karl that wasn't a pla-, I didn't plan to stop studying physics. I was planning to take a break. Cause I thought, it was, it felt a bit, ehm.. this is hard to explain in English, it's hard to explain in Swedish as well, but – distant from … from the world. It felt like I was studying something that was separated from people.

I mhm

Karl I was feeling right then, that I'll be more interested in doing something that was closer to… human beings, than numbers and… and particles and the universe as a whole. So… … So that was the reason. So then I went back to humanities. I studied [redacted]. And when I came half through that I heard about what I'm taking, what I'm planning to do, is [redacted] studies. So, then I changed my mind. Decided I wanted to be a social studier, work with social science instead.

I mhm. Yeah, I guess it wasn't a hard decision for you to take either, since you already had a lot of stu-, I mean how much of the previous stuff you've read, can you bring into your exam?

Karl not much. I mean I suppose I can, but it wouldn't… I am not planning to use the courses I've done before in that exam. So I've been studying at double speed now to get my degree.

I ok, hehe

Karl Yeah. In social science. Cause, so it was a hard decision. I mean, it was a hard decision cause it changed my way of thinking of what I was going to do. Because I've been thinking about physics for a very long time. So I mean, it wasn't easy, and I knew it would take more time to study social science then it would to go back and study physics. But… I just

I ok, you didn't take the easy choice

Karl no, I don't think so. It would have been easier, and I mean I was already on track studying physics. And I didn't, I felt I could manage without too much work. I, of course, it would have taken more work, had I continued to, had a few courses for example, this semester, I did el-läre, electricity or something, perhaps not the hardest course in the world, that either. Still I am sure it would have taken more effort, but ehm... I think compared to for example writing a c-uppsats [a paper], I think it would not have been much more work for me, to study physics. So I didn't consider the workload really. I was thinking about what I wanted to do. It wasn't

I what you wanted to do when? At the end?

Karl yeah, working, what I wanted to work with.

I Yeah. Ok. So you are saying that the main reason for stopping physics was that it was kind of removed from the world, or it didn't have anything to do with people?

Karl yeah...

I Can I say that it seemed like it didn't have any practical implications?

Karl ... Well, no I don't think so. Cause I mean, practical implications... ehm... It's not really the same thing. I mean you can do things with physics that has obvious practical implications, and that has very sort of on-hand implications for everyday life, if you want to. I mean if I changed over to mechanical engineering or something, I could have build an engine and help people get to work. I'm not sure. But I mean, that's practical, even more practical I think than [redacted] studies. You can spend all your life doing something that was obviously wrong in the end. So it won't help anyone. But more like. I felt, back then I felt the people I wanted to closer to. Work with people, I just felt it was more interesting.

I yeah

Karl and its. Not sure how to, I mean its

I But I... No, but lets, I mean, try out different possibilities of working with people

Karl mhm, sure

I , because you can be talking about working with people like everyday when you go to work you

are talking to people, or you can talk about working with people in the sense that people are what you work *with*.

Karl yeah, it's more like what people I'll work with, and understanding people is what I do. And the effect is what I do, or is more... yeah, people is the subject of what I do... yeah, its probably the best explanation for it in the end.

I yeah?

Karl yeah!

I ehm, I really think I understand what you mean, ehm

Karl good.

I ... but I'm just...

Karl you have to make sure

I no, no its more like I'm trying to understand why physics came, why you actually started studying physics, but that, I guess that was because it's always been a plan

Karl [.....sigh.....]

I for you, I'm trying to sum up my understanding of it.

Karl yeah.

I And you wanted to be-

Karl I mean this is problem solving I think. Always, pff... I mean then I always had pretty easy to do this physics. I mean and I had an interest in physics. I have an interest still, in understanding how the world works, and how, why things happen as they do.

I mhm

Karl So it's not... that's... hmm... it's probably the same thing. Most people will tell you if you ask them 'why physics', I think it's partly the problem solving, partly the interest in the subject, and what you study. And then at the same, and probably a part of it as well, the, how do you call it, prestige in physics. As a, ehm, intellectual work... So

I You, you think there is prestige in being a physicist?

Karl yeah

I also being a physics student? Is that prestigious?

Karl ... yeah if you compare to art student anyway. Pff... yeah, I think it is.

I But being an economics student or a so-

Karl yeah, I mean if you compare them, yeah I think there is. Especially if you compare economics student, in pure status. I think physics student probably are the one going to the highest in their own, and in other peoples mind, for being the ones most. I mean the brightest people. If that is what you measure.

I yeah, if intelligence, high IQ was the measure then physics would b-

Karl yeah yeah

I But how about social intelligence?

Karl … …

I I mean

Karl yeah, but I… [sigh]… There is a lot of ehm. I mean this institution or this house all the people harboured, harbour so many people, every ones knows that social ehm, social competence, or what do you call it social…

I yeah.

Karl And physics, there is no absolute, there is no, *what do you call it?!* Conflict between them. So I, and many people I know who study physics are social very pleasant people, so. So I never experienced it as a conflict between them. And I didn't think there was when I quit studying.

I No.. I mean, and I think that its a major cultural difference between Denmark and Sweden. Because I've always been a bit ashamed of when I was student in Denmark of telling people when I met them, that I was a physics student, because it would brand me as a nerd.

Karl yeah ok

I Ehm, but I mean, I haven't met any Swede yet

I who's talking about nerds actually. And you don't either.

Karl Noo No, but I've never really thought about nerds.

I no?

Karl I mean, if you go back to gymnasiet, the nature programme, already there you make, the people studying nature are sort of the same distinction. No-one, but *they* don't think of themselves as nerds. We just: 'we are the ones who are going to do this'. So…

I mhm. But don't you have nerds within that grouping? I mean you can, as far as I understand that choosing the natural science programme in gymnasium, is because it makes sense. You can get in *everywhere*, if you take the samhällsvetenskapliga you need to, you know, add on a bit of courses to be able to study science for instance

Karl yeah

I So that's why it makes sense. People who are academically 'fluffy' they choose it as well as the ones who know where they want to go.

Karl yeah.

I But… I mean, have you ever met a nerd?

Karl haha, I met people who'd. But a mean a nerd is an American word I think. It is not *as* obvious in Sweden. I mean I had many people in my class who were into computers and setting program at home and built there little, what do you call them? Pff, robots and so, in Lego. And not uncommon. But perhaps there was, but I never experience there was any big social.. Perhaps some people did look down on them, I'm not sure, I never really experienced it, and if they did, I can't really say that I care. And I, yeah. So

I But maybe it's just American and I don't know, maybe also Danish that you have this. I mean I *know* what a nerd is. It's a person who is interested in science and has week social compencies to the brink of almost seeming stupid, but actually show signs of intelligence in order to be able to actually succeed *well* in physics

Karl yeah mhm yeah

I and that actually having a week social side, makes you more able in physics because then you can spend your time at home, you

Karl yeah

I can do the stuff without talking with too many people, or without talking about different stuff when you actually work together with people. And you don't spend every Friday

Karl mnjaa

I drinking your head out, or brains out.

Karl Haha, [inaudible sentence], yeah that might be, but its not… Not at university. Not in Uppsala. I mean there is too many of them. Too many people studying physics or technology in this build-

ing, or in Uppsala as well as a whole, to... Perhaps there are, I mean there are probably some socially incompetent people – or incompetent but not as competent as other

I yeah yeah yeah, it was just to put it the head or

Karl yeah, so, I mean they probably have problems, if you have social problems, and then you have social problems. And perhaps more of them study physics but it's not, it's not... I never think, and perhaps there are other people in, perhaps studying economics that think that there is an absolute connection between studying physics and being one of these people. But it's not something that normally developed person would automatically assume so I mean, its not

I hahaha

Karl , you are not absolutely put in the... Fuck, what do you call it in English. In that box, because you study physics, its not per automatic, I think.

I no I agree with you, it's not that at all, it's just, ehm, the reason that I'm talking to you and not some guy who is studying economics is because you've been here, and you've seen how it is and you

Karl yeah of course, there are people who are socially, has problems socially, and perhaps, because of that is more accomplished at physics, and perhaps even for that reason, choose physics as a subject. But ehm... ehm, it's, I don't think that, that makes an, makes people do the connection between physics, and having that personality. At least not in such a degree that it affected my decision not to study physics, cause I don't see the link. Well I don't think other people see the link that strong. And if they do, I don't really care what the people who do, see that link, think, cause then they make a stupid link, and I would simply disregard that.

I hehehe God damit that became complicated.

Karl hehehe Yeah, but I mean, it didn't affect my decision cause I don't think people see

I in simple terms, what you are saying is: It was not because they were nerds, and I wasn't?

Karl No, no absolutely not.

I that is what you are saying?

Karl yeah. Haha, Cause I mean, haha, that's a totally other thing, I mean... I was always, or always, but I was closer to being a nerd than I was to being a nerd, than I was to being the cool guy. So I've never sort of been the cool guy. So it's not. I mean my, so. I never really, I've never considered, I mean many of my friends were what you probably would describe as nerds. Or at least computer geeks or something, in gymnasiet for example. So that has never been a...

I You seem to have an opinion on it though. Even though you say that it's not an issue.

Karl yeah, haha, of course.

I I mean like you've been asked the same question before? Is that-

Karl Yeah.. it's hard to explain. Of course there is... something. I mean you've spent so much time thinking about social things, so you have an opinion about most things, but. Of course we are all affected by platitudes of nerd and school and chuppa chuppa [meaning more layers – kind of 'etcetera'], but I mean it's my experience that *that* grouping isn't as strong in Sweden as it is perhaps in other countries. And in the sense that does exist... and it does... I mean... ehm, this is complicated, especially in English... ehm.... .... So I'm trying to decide how to explain it.

I yeah yeah, take your time.

Karl hmm... ... or my view of it anyway... ... ... cause there is always, if you are the smartest guy in the class for example, then you sort of get a brand by being that. Or if you spent a lot of time studying people will always judge you for it, or see a special way for it. And that of course exist in Sweden as well. But... ehm... Personally I'm... I've been more of one of the guys who did good in school and therefore I never sort of felt... I've never been part of the g-. If I may say, to pat my own shoulder a bit, I never felt that I've been one of the people thinking of other people: 'they are nerds, cause ...'. Cause, yeah, and why that is, that's probably.. yeah, I never felt really being a nerd myself either.

I Ok, because that would be my next question.

Karl yeah, cause perhaps, pff, not as such. And of course I have had social problems. I mean *social problems?* But I have had, when I was growing up, like all other

people growing up you are a bit insecure, and you.. yeah, but I never felt-

I you struggled with finding your own identity and so on.

Karl exactly, but I never felt mobbad [bullied, victimized], what do you call that?

I ehm, teased... in a bad sense

Karl teased... nah, teased is something else. In more, mobbad is a worse degree than teased. I mean teased, you are teased by sisters everyday, I mean that's something different.

I Somewhere in between harassed and teased, I don't know what that is.

Karl exactly, but anyway. So I never felt that way, that I've been totally out- ehm, been outside like a nerd. I never felt that way either. So I've been. I felt I've been sort of in between. I've been in the group. I've not been the leader of the group, I've not been the nerd, I've not been the... the one harassing the nerd, and I've not been [a sound sounding like totfee totfee totfee, [meaning 'etcetera']. So in then, I felt ehm sort of didn't identify myself in that context. Between being a nerd and outside.

I Ok. But how do you react to people who do make that distinction. For instance the one who harassed the nerd, or the one who was the nerd. You didn't identify the nerd, I'm pretty – that's what you said.

Karl haha, well, you can identify the person that would have been the nerd, or that people would have harassed. But ehm, I've not been in a group where the nerd in the end has been. Or perhaps he has, but I've not seen it. But when I'm in a group I try to make sure that no-one is harassed, in the best of my abilities of course. I'm not sure if I can see it, or if I can do something about it, if every time you are there. But when I.. I never... ehm... But when I've seen it, I've seen it starting to happen, I've tried to stop it, cause I mean, it's, in the end, pretty silly, to... so...

I yeah.

Karl ... it's a silly distinction, simply. And most people who realize that it is a silly distinction, if you. I mean, you don't make the distinction cause you.. cause you it's true. You make it for other social reasons so. I mean, if they are not, if you don't gain anything by calling someone a nerd, you won't in the end do it. So.. that usually

I nah, that's not true.

Karl what?

I that's not true that

Karl ok?

I just because you don't gain anything on it you won't do it.

Karl ah, ok?

I … well, I'm I don't know, I'm just thinking that there is a lot of shit happening in the society and in the relation between both children and young people and so on

Karl yeah

I that has, I mean that is bad for people. That was just-

Karl yeah, I mean, I mean what I mean is, if you have a social group, and you want to harass someone you must. To do that you must gain something from the rest of the group.

I mhm yeah, for instance acquiring leadership

Karl Exact, for example, or just acquiring acceptance for example. I mean if you take the people who harass, this is not – I'm *not* studying psychology so I don't know this, but it's just my own thinking on the subject – but if you take someone who harass it's usually not the *leader* it is usually someone who wants to, to who's pretty low on the food-chain if you describe it that way, and who wants to climb or be acknowledged who harass the nerd who can't defend himself or herself. So if the rest of the group indulge that behaviour then he won't do it.

I exactly

Karl And for example my, at högstadiet, I can't really remember cause then we were all sort of running around and being strange people.

I mhm!

Karl At gymnasium, that's perhaps the advantage of this segregation that occur with naturvetenskap/Samhäll and all the rest of the people. That you get this naturvetare, and they are all in a way interested in studying, for example, or going to university. Not all of them perhaps. But most, so then

you don't get an environment where it's alright to pick on someone because he is good in school.

I Where there is a minority that..?

Karl That want to be good in school. Or at least, in my group I had, the ones who were obviously leading the group wasn't people who would harass someone cause they are... ... accomplished or smart or...

I mhm. Ok, there is a couple of things I have to ask you now.

Karl ok, haha

I Högstadiet you already did a separation there it appears?

Karl sorry?

I In högstadiet or before högstadiet you already chose

Karl: yeah? No, not before högstadiet, after.

I ok, so after. Yeah

Karl Before högstadiet we ha the same classes from first we started school to högstadiet.

I including högstadiet?

Karl including högstadiet.

I good. So that was my. But it just sounded a bit like you already had a separation before.

Karl no, no..

I Did you go to private schools?

Karl no

I ehm... ok I think that was the questions that had been building up... I ehm... hmm.

Karl but it was a small town, I mean, so...

I yeah...

Karl or small town. 20.000 thousand or something, people, perhaps.

I yeah, so that should mean that people in the school could come from every layer of the society?

Karl yeah

I working class to upper class and so on? Yeah. Good. So you actually oppose a distinction of, no oppose putting people in boxes?

Karl hmm... Yeah, I mean... It's hard to say, it's always. That a definition of what you define as a box anyway. I mean you always have an image of a person. So in your own head you put them in a box, or her. But I don't think it's, yeah to make a distinction, and by that distinction knowingly, by that destinction make, I mean, use the person in special ways.

I yeah, I know what you mean

Karl yeah, I mean it's always a problem to talk in absolutes – distinction of people by broad definitions.

I yeah... you said that there was ehm. That there simply is too many physics students here

Karl too many?

I No

Karl I said that there *are* many.

I yeah but

Karl yeah too many to make all of them nerds.

I yeah exactly and too many, to make a, what do you, too many to make a – what do you.. not an archetype, but more like a... ehm.. what ahh..

Karl yeah, but an archetype.

I I mean that people are too different simply because of their numbers, for other students or other people who actually have access to

Karl yeah, and I mean you meet them everywhere.

I mhm.

Karl And if you meet enough people that doesn't fit your archetype of that group you can't have that archetype. I mean it's You should, I'm not sure

I no

Karl that it is but ... It should be possible for most people.

I mhm. In terms of archetypes, do you think that there is something that, that I mean, a quality that you have to possess to be able to do well in physics?

Karl .... No. I don't think. I think you, you have to, I mean you have to have the qualities that all people have to succeed. But I mean, I don't think you have to brilliantly smart. I think you can compensate by working very hard for example, if that is what you are asking, because that might be what you are asking. I think that's...

I yeah No, I'm not trying to cloud my questions.

Karl No, but. No ok. But it could a question: Do I think that people have to be smart to be a physicist.

I mhm

Karl And I think you can compensate by working very hard. And you can, I mean, I think. I have another opinion about people being, I mean.. People who chose to study physics, usually do good in math. And people who did good in math, think they *can* do good in math, people who start out doing poorly in math usually think they *can't* do math at all, and after a while decide that they can't do math, even though, if they tried and worked a little on it, they probably could do alright. So I think you have to choose and to be good in physics, you have to believe that you can do well in physics. And if you believe you can do well in physics and want to do it, then you can... it's that yeah, if you are not

A note on the type

The text of this licentiate thesis has been set in a slightly modified Goudy Old Style, one of the more than one hundred typefaces designed by Frederic William Goudy (1865-1947). Although Goudy began his career as a book-keeper, he was so inspired by the appearance of several newly published books from the Kelmscott Press that he devoted the remainder of his life to typography in an attempt to bring a better understanding of the movement led by William Morris to the printers of the United States. Produced 1915-1919, Goudy Old Style, Old Style Italic and Old Style Bold reflect the absorption of a generation of designers with things 'ancient.'

Goudy Old Style is a graceful, balanced design with a few eccentricities, including the upward-curved ear on the g and the diamond shape of the dots at the i, j, and the points found in period, colon and exclamation point. Also notable is the uppercase italic *Q*'s and *&*'s strong calligraphic qualities, and the roundish upward swelling of the horizontal strokes at the base of the E and the L.

Its smooth, even colour combined with the generous curves and ample cut marks it as one of Goudy's finest achievements.

The most notable modification of the true-type font used in this thesis is the realignment of the figures, that in the original typeface were centred round the bottom half of the text-line.

Only charts produced in the Microsoft® Excel spreadsheet are excepted from the general use of the Goudy Old Style font. These are set in Times New Roman, a standard in the Microsoft® Office 2002 foundry.

Sources:
Gay Talese (2006). A Writer's Life. New York, Alfred A. Knopf.
www.Wikipedia.org and www.Linotype.com