Study on learning sources and learning time in the Formal Specification and Verification course in WS 2006/07*

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Abstract

The aim of the project is to investigate a question when and how students learn. The information has been collected by means of periodically conducted questionnaires. The goal is to adapt the structure of learning sources to students' expectations and needs. The analysis of the results shows that students are satisfied with the lecture, nevertheless some improvements for exercises are necessary.

*prepared as a project for the didactic course at the University of Innsbruck

Contents

1 Case description

A brief description of the course in question, the students attending it and the possible learning sources and time are given in this section.

1.1 The analysed course

I gave a course *Formal Specification and Verification* (FSaV) in the winter semester 2006/2007. I am the lecturer (LZK 703603) and partially tutor (LZK 703604), I had two out of three exercise groups.

The course structure The course consists of three topics: (1) axiomatic semantics, (2) algebraic specification, and (3) model–based specification.
The first part is related to the *Semantics of Programming Language* (SoPL), a course given in the summer semester 2006. Even the same text book as for SoPL is used for the first part. The other topics are a bit related to the prior courses, for example *Logic*, for bachelor and master programs.
The exercises are strictly related to the lecture and conducted in parallel up to the topics.

The target group The course is designed for master program students and is given in English, that is neither students' nor teachers' native language. The number of active students at the end of the term was 55, that corresponds to 21, 17, 17 students in each group, respectively.

The first part of the lecture is easy to learn for the students who have covered the SoPL course, nevertheless taking SoPL is not a strict prerequisite for the FSaV course.
Special attention has to be paid to students from the *Computational Logic* (CL) stream. The FSaV course is, as it has been mentioned before, rather a formal course and as CL students are more experienced in logical programing and logic as such, they are succeed better.

1.2 Provided learning sources

The following sources of information and learning aid mechanisms are provided by another tutor and myself:

- **lecture** as a talk, the time slot is rather not motivating (Mo 8 a.m.),
- **slides** for the lecture are available on–line,
- **web page** with additional information sources
  (links to specifications, manuals, and the like).

I have to mention that there are neither a text book for the lecture nor hand-outs. The content is a compilation based on chapters from a variety of books, mostly available on–line, and other information sources (e.g. specifications).

1.3 Students initiative

Students can find other sources of informations themselves:

- **additional electronic sources** to be found in the Internet,
- **additional paper sources** to be found in the library,
- **traditional team work** with other students (learning meetings),
- **virtual team work** with other students via the course mailing list or direct e–mails, as well as to the teachers.

1.4 Time distribution

The other interesting issue is when students learn. Here I have considered the following possibilities:

- **pre–knowledge**, gathered from prior courses or reading materials,
- **lectures** with the following variations:
  - looking through slides before the lecture,
  - lecture attendance,
  - slides revision after the lecture,
- **exercises** with the following variations:
  - preparation for exercises, reading manuals, additional materials, preparing own solutions,
  - during exercises, doing tasks, solution presentations by other students,
  - revision of exercises or discussion with other students,
- **exams**:
  - preparation for the exam in comparison to time spent during the whole term.

1.5 Motivation

The fact that I am involved in both lecture and exercises gives me an opportunity to harmonise them and make a learning process easier for students. At this place I would like to add that the course is rather formal, which makes it difficult for a significant number of students.

With this project I would like to find answers to the following issues:

- Firstly, what percentage of knowledge do students learn from teachers and provided sources? Secondly, what percentage they get from additional sources, and thirdly, from other students?

- When do students learn: regularly during the whole term or just before the exam?
- What are students' expectations?

The results should allow me to hold a better balance of the amount of information given at the lecture, the exercises and on–line.

2 Information collecting

The information has been gathered in a few steps, listed below, in form of a paper questionnaire.

1. After the introduction lecture I conducted an exploratory data collection to familiarise students with the questionnaire and eventually obtain some suggestions from them on aspects not mentioned in the questionnaires, but important for the study.

2–4. After each block of the lecture (see section 1.1).

After the preliminary data collection (on 9th October) I obtained a suggestion to integrate time consumption for learning and exercises preparation. This suggestion was very interesting and I have integrated it into the questionnaire form.

Due to limited time I had only two data collection sessions: the first for axiomatic semantics (on 13th November) and the second, joined session for algebraic and model based specifications (on 15th January).

3 Data interpretation

Interpretation of the obtained results are presented in this section. The gathered data have been interpreted in both quantitative and qualitative aspects. Frequency distributions have been used for the quantitative analysis (section 3.1), whereas comments from students have been interpreted and summarised for the qualitative analysis (section 3.2).

3.1 Quantitative results

In this section the quantitative interpretation of the collected data is provided. At first, general information, quality of data and guidelines for diagram interpretation are described, then the results of all sections of the questionnaires are interpreted.

3.1.1 General information

28 and 30 questionnaires have been collected in the first and second sessions, respectively. There were 55 active students at the end of the course, thus, the collected opinions cover more than the half of the students population (51%, 55%). This is also the average rate of students attending the lecture. As it has been mentioned in section 1.2 the time slot for the lecture was a bit discouraging, thus I am satisfied with such an attendance rate.

3.1.2 Quality of data

The collected information has been partially incomplete, as 28% of questions in all questionnaires were left empty. This is mostly because of summary questions (left empty in 71% of cases) and preferred state information (9% left empty, excluding summary data). There is one questionnaire filled completely with zeros, this one I have excluded from the analysis.

3.1.3 Diagram description

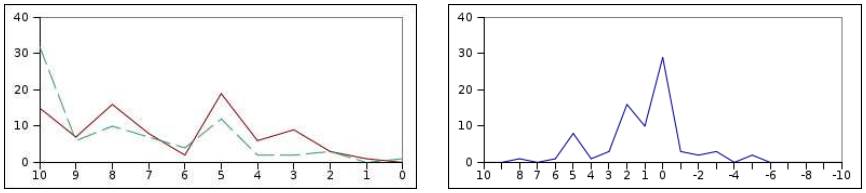
I use mostly two types of diagrams in the following sections. One with the results obtained for the current (red, solid lines) and preferred state category (green, dashed lined). The values on the x–axis range from 10 to 0. The second type shows the difference between the preferred and current state (blue, solid lines). The values on the x–axis range from 10 to -10. The negative values mean that the expectations of students are lower than the current state.

3.1.4 The learning sources

The information sources provided by teachers and those information found by students are analysed in this section.

Provided sources I have considered three different information sources provided by myself, namely the lecture as a talk, slides for the lecture and the web page. The talk and the slides have obtained quite a high rate, with a mean of 6.53 and 6.80 points, respectively. In contrast, the web page is not found so useful, with a mean of 3.77.

Most students are satisfied with the current state, shown in Figures 1(b)–3(b). 37% students would keep the amount of information at the same level, 51% would prefer to have more and 13% less information. For the slides, the results are even better, 46% of respondents consider the current state optimal, 33% would prefer to learn more from slides, and 21% to learn less. The results for the web page are not so far from optimal, as one could expect based on the mean score. 35% of students are satisfied with the current state, 41% would expect more information and 24% would expect less information on the web page.



(a) current, preferred (b) preferred - current

Figure 1: The lecture as a talk

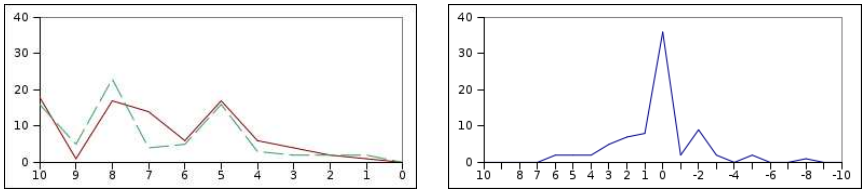


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Figure 2: The slides as a reading material

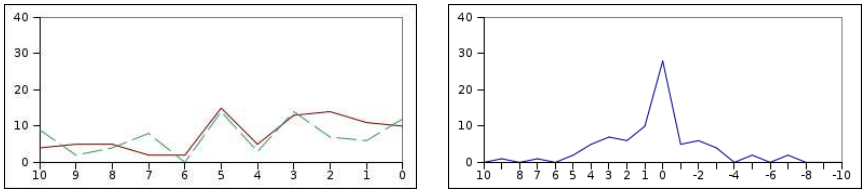

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Figure 3: The web page with the provided links

Students' sources It seems that students do not want to search for other sources of information. 33% of students learned nothing from additional information from the Internet (Figure 4) and 89% of students learned nothing from additional information sources in paper form (Figure 5). They look for some information in the Internet, 38% of students assigned 1–5 points to this category, and 28% of students granted 6–10 points. The current state covers more or less the expectation of the students. Only 10% of students assigned 1–4 points to the category for additional paper sources. *Students do not look for the additional sources, especially in paper from, and they do not want to do that.*

However, there is not a clear trend in the current or preferred state of the team work (Figure 6), the students would prefer to work more in teams. Although the exercises were thought to be individual, students did them in teams and performed acts of plagiarism. The trend for virtual team work (Figure 7) is quite different. In this case the average is lower than the one for the traditional team work (2.35 and 5.05, respectively), and 44% of the students do not cooperate in a virtual way. *Students work and want to work in teams, especially in a traditional way.*

3.1.5 Time distribution of learning process

Pre–knowledge The rate of the pre–knowledge is rather low, 2.3 points. There have been very few students whose pre–knowledge has been greater than 5 points (8%, Figure 8).

There is no relation between a stream and the pre–knowledge self–evaluation. I have expected that CL–students would have more pre–knowledge, but it hasn't been confirmed by the collected data. It is not possible to judge this fact in an objective way as it was a self–evaluation.

My expectation regarding the pre–knowledge rate for the axiomatic semantics has been confirmed. For the axiomatic semantics the mean score evaluation is 3.14, where for other two topics it is 2.03 and 1.83, respectively. I want to emphasise here that the first topic was related to SoPL course taken by the students in the summer term.

Lecture It seems that *students in general do not read the lecture slides before the lecture* (Figure 9). This trend is clear. Half of the students do prefer to learn more before the lecture as it is hardly possible to learn less. The quantitative analysis of this fact does not answer the crucial question, why the students do not read the slides before the lecture. Is it because of lack of time or because the slides were provided on–line too late? Unfortunately the qualitative part does not answer this question.

Almost half of the students (48%) assigned the maximal number of points as a learning factor during the lecture and 67% of students are satisfied with the current state (Figure 10).

The situation with "reading slides after the lecture" (Figure 11) is much better than "before the lecture". Students learn a lot by reading the slides after

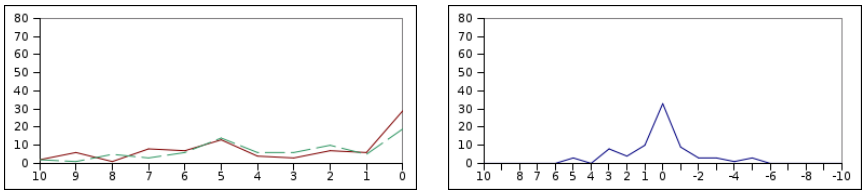

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Figure 4: Additional electronic sources found in the Internet

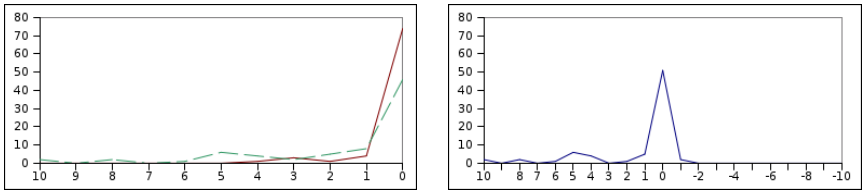

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Figure 5: Additional paper sources found in an library

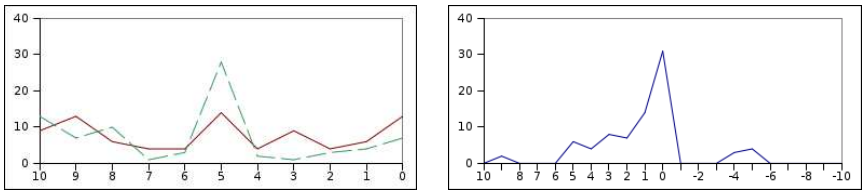

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Figure 6: The traditional team work with other students

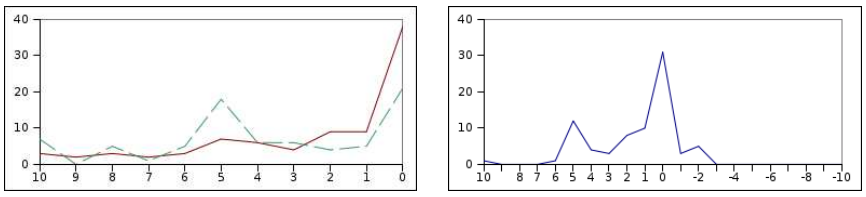

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Figure 7: The virtual team work via the mailing list, e–mails, forums

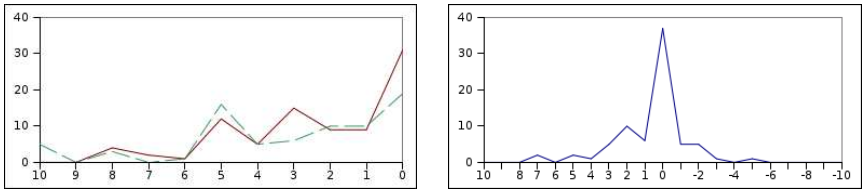

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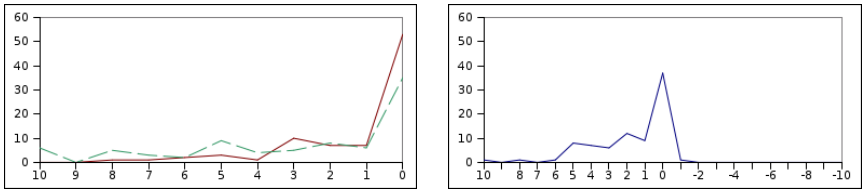
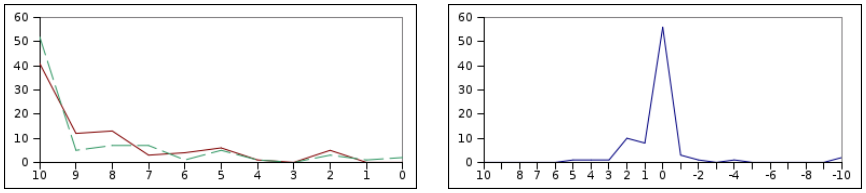
Figure 8: The pre–knowledge of students



(a) current, preferred (b) preferred - current

Figure 9: Reading the slides before the lecture



(a) current, preferred (b) preferred - current

Figure 10: Attendance at the lecture

the lecture, the average rate is 6.33, while for attending the lecture it is 8.36 and for reading slides before the lecture it is only 1.14.

Exercises The situation with exercises is quite different than with lectures. Students are to prepare solutions for exercises by themselves (in teams?) before the tutorial. Thus, it is obvious that they learn more before the tutorial (the rate is 6.98) than during or after the tutorial (rates are 5.42 and 4.09, respectively). The students would like to learn less before the tutorial (Figure 12) and probably invest less time in doing exercises (see the next section). They would prefer to learn more during and after tutorial (Figures 13–14).

3.1.6 Time invested per week

This is an additional category added on request from the students after the preliminary querying. There are two questions in this category: how much time students invest in learning each week, expressed in hours, and how much time they invest in solving exercises. The results are grouped in 5–hours blocks in Figure 15. In general students need more time to do exercises than to learn the material. The students accept the time necessary for learning, but the average tendency has shown that this time could be reduced by 5%. 39% of the interviewed students would like to reduce the time, 49% of them accept the existing time amount, whereas 12% of the students would like to increase it. *The time amount was hardly acceptable for the problem solving.* On average the students would prefer to reduce this time by 30%. 71% of them would like to reduce this time, whereas 24% of respondents would accept it, and 5% of the interviewees would increase it.

3.2 Qualitative results

Unfortunately there were very few comments, thus, I decided to cite all of them here, as they refer the major issues.

L E C T U R E:
- more detailed study of fewer topics
- more focus on theory than programs
- blackboard examples are very good!
- the slides are the best source for learning and are very helpful

E X E R C I S E S:
- more precise description of tasks in exercises
- more explanation of exercises at lectures
- with the last part of exercises I have had major troubles because of poor usability and stability of tools
- more information and help with HOL–OCL

The first problem is of general nature, the tools supporting formal specifications are not so mature as tools for program development. According to

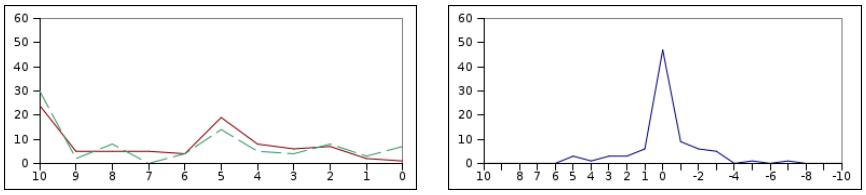


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Figure 11: Reading the slides after the lecture

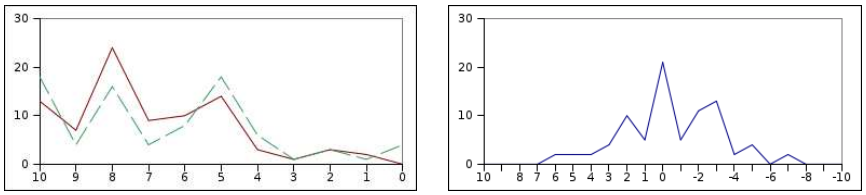

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Figure 12: Preparation for the exercises

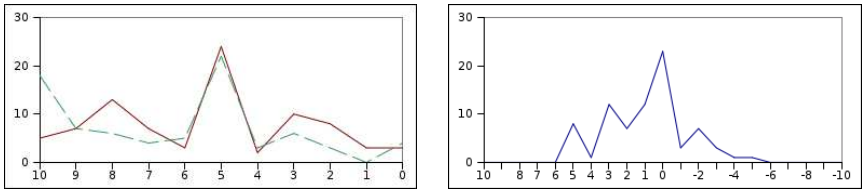

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Figure 13: During the exercises

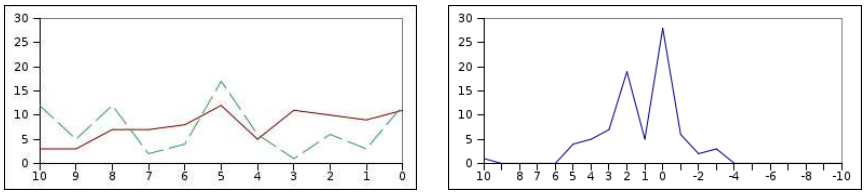

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Figure 14: Repetition of the stuff from the exercises

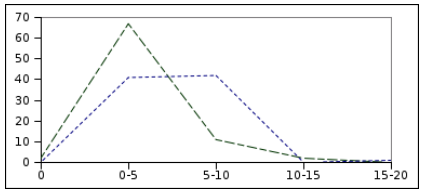

Figure 15: Time invested in learning and exercises solving

my observations and own experience the tools are not user–friendly and stable. It is hard to work with such tools but there is no alternative. Students needed to invest much more time only because of poor quality of tools and their documentations.

The second problem is how to find a balance between time limitations and stuff to be taught. This problem should be solved in the new curriculum for computer science where there is a mandatory lecture and optional exercises. The lecture will give an overview of all methods and in the exercises only selected methods will be investigated in a more detailed way.

4 Summary

This section is split into three parts, the first one deals with the interpretation of the feedback, the second with possible improvements based on feedback, and the last one is a reflexive part, where the method of project conduction is investigated.

4.1 Feedback summary

In my opinion the students take the questionnaires seriously and I assume that the results reflect their evaluation of the course and show their real expectations. The results presented in section 3 are analysed below in the context of questions from section 1.5.

How much do students learn from teachers and the sources provided by them, from additional sources, from other students? According to the quantitative results the students learn a lot during the lecture and from the slides. They do not look for additional sources of information especially in a printed form. Students are used to work in teams and prefer team work to individual work. According to my observations students also learn for exams in teams.

When do students learn: regularly during the whole term or just before the exam? This question can not be answered as no data have been collected.

What are students' expectations? Students are satisfied with lectures according to the collected information. The correlation between lectures and exercises needs to be improved. The range of exercises could be probably reduced.

4.2 Possible improvements

The obtained feedback has three aspects: perception of the lecture and of exercises as well as interdependencies between them. All aspects are described in the following sections.

4.2.1 Lecture

According to the quantitative and qualitative data I propose to introduce the following improvements in context of the lecture and quality of its delivery.

Content of the lecture. According to one of the comments the lecture looks like an overview and all the mentioned approaches have been explained not in–depth enough. This has actually been my intention to have such a lecture, but it seems that it has not been clear for the students. Next time I would explain it in the introduction lecture. As it has already been mentioned before only the lecture will be mandatory and exercises will take place one term after the lecture and will be optional in the new curriculum. In the new version of the lecture I want to have an overview of all main specification types and in the exercises focus on one or two methods only.

Quality of the lecture delivery. The slides of the lecture are well perceived by students, but the delivery should be improved. I will take the course on *Presenting and discussing scientific results in English (2728)* next term to improve my presentations skills which I hope will be useful for didactic presentations as well.

4.2.2 Exercises

The typical modus of the exercises is that the students obtain sheets with exercises to be done at home. I distinguish two issues here. The first problem is that exercises' solving takes too much time. Due to the commonly accepted exercises modus the students need to learn a lot by themselves and prepare the solutions on their own. The second problem is related to objective and fair evaluation. As students work at home I am not able to judge if students prepare the solutions by their own, in teams or copy the solutions from other students. That is only possible for the individual students who present their solutions during the tutorial. I plan to conduct the exercises in a form of a project where students will work in teams (by default) and will work on a larger specification to avoid these problems in the coming terms.

4.2.3 Lecture–Exercises

The students would like to have more assistance for the exercises. It was hard to implement it in the previous term because of time limitations. It should not be the case in the new curriculum where lectures and exercises are separated. There were three academic hours per week for the complete course in the last term, two of them were designed for lectures and one for exercises. The time for lectures will remain the same but the time for exercises would be increased to two hours in the new curriculum. Thus, it should be possible to revise and extend the content of the lecture in the exercises and give some more extended introduction to the used tools. I hope in the new version it should be easier for students to learn more.

4.3 Method review

To design questionnaires is a demanding task. As I have analysed the questionnaires I have noticed that clear and unambiguous formulation of questions is crucial for interpretation of the results. For example, the interpretation of low value for the question on the knowledge gained by reading the slides before the lecture is not clear, on the one side it can mean that slides were of poor quality on the other side that students have no time to read slides. I would use this question as a contingency question and then ask students about amount of time they spend to read the slides, the quality of slides etc.

I also provided summing up question and I have noticed that a lot of students (70%) skipped this type of questions (the rate of unfilled detailed questions was 6%). I think such questions could be eliminated from the questionnaires and substituted by contingency questions.

Due to time reasons I have conducted the second and third questionnaires on the same (last) lecture. To save forests I have even combined the questionnaires forms to have a single form for both investigated topics. This narrowing of time and space caused almost identical answers for the last two topics. I think the results should be interpreted as an average for both topics.

I would focus next time more on preparation of the questionnaires based on social science methods and questionnaires collections to obtain more reliable information. I would even select other means for evaluation like interviews to get more qualitative information. It was not possible to apply mentioned methods for this project due to time limitations.