

Learning MATLAB: Evaluation of Methods and Materials for First-Year Engineering Students*

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The paper describes the development of a MATLAB course as part of a first-year introductory engineering course 'Perspectives of Vehicle Engineering' in the MSc programme in Vehicle Engineering at the Royal Institute of Technology (KTH) in Stockholm, Sweden. This course is intended to give core engineering knowledge and experience, and to prepare the students for their studies in engineering mechanics and vehicle engineering. The expectation is that the students, upon completion of the MATLAB course, will have acquired the ability to use MATLAB in later courses in the curriculum where MATLAB is chosen to be the primary computational and visualisation tool. The development work was divided into three parts. The first part contained a preparatory phase in which the work was planned, the purpose and objectives formulated, the course content and implementation planned, and suitable instructional materials identified. The next step was to select a student test group to go through a trial run of the course, using the different options available for instructional materials. The experiences obtained from the test group's efforts, and their results, were the basis for carrying out the first year of regular instruction of the MATLAB course. In the third and final phase of the course development, it was given for the first time as an ordinary part of the curriculum for first-year students in the KTH vehicle engineering program. The results and experiences obtained from that 1st year will serve as a basis for modifications to the MATLAB course to be given in later years.

INTRODUCTION

THE COMPUTATIONAL and visualisation program MATLAB [1] has become a very popular tool in research and engineering, as well as in engineering education. The MATLAB concept is undergoing rapid expansion, while very powerful, yet dimensionally small, computers are becoming available; in our opinion, this will eventually lead to the replacement of the types of hand-held calculators first introduced at the end of the 1960's and beginning of the 1970's, by MATLAB-based systems or something equivalent. The rapid growth of the so-called toolboxes, in which more specialised subjects are featured, means that many researchers within the engineering and mathematical spheres see the opportunity to disseminate their methods and results to a wider audience. For technical universities, these developments imply that the theoretical methods that have long been known and traditionally taught, are vastly more accessible to the students, both during and after their formal education.

Conventionally, engineering students have been introduced to MATLAB and other computer-aided engineering tools during higher level applied engineering courses. This requires extra time and effort from both students and instructors and contains risks to the overall outcome [2–5]. How

MATLAB is used in some specific courses and the benefits of its use is described for example in [3, 6–8]. A large number of textbooks using MATLAB and course materials are available from the MathWorks website [9]. Daku *et al.* [10], have developed an interactive CD-ROM-based tutorial for MATLAB: M-Tutor [11]. Another, still less common approach is to teach MATLAB and other 'standard' software tools in a separate course or during an introductory engineering course for freshmen [12]. It is widely recognised that better co-ordination between different courses using computer software will enhance student learning [2, 13–14].

In autumn 2000, the Department of Vehicle Engineering (now called the Department of Aeronautical and Vehicle Engineering) at the Royal Institute of Technology (KTH) in Stockholm, Sweden, was given the task of including, as a part of the course 'Perspectives of Vehicle Engineering', an introduction to MATLAB. This course, as its name implies, is intended to give a broad overview of the subject, to introduce newly arrived students at KTH and their instructors, and to prepare the students for their studies in engineering mechanics and vehicle engineering. The course is being revised for the academic year 2003–2004 in order to more fully incorporate aspects of the CDIO Initiative [15]. CDIO stands for Conceive—Design—Implement—Operate. CDIO is a collaborative program for engineering education reform, initiated between KTH, the Chalmers

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University of Technology, the Linköping Institute of Technology of Sweden and the Massachusetts Institute of Technology (MIT) of the USA, and supported by the Swedish Knut and Alice Wallenberg Foundation. More recently, a number of technical universities around the world have joined the framework. The program activity is thoroughly described on the CDIO website [16]. Current information on the course ‘Perspectives of Vehicle Engineering’ is available from WWW [17].

The curriculum committee in the subject area has decided that MATLAB will be the fundamental computational and visualisation tool used throughout the curriculum, thereby more effectively ensuring that the theoretical knowledge and methods acquired during the entire educational program can be translated into practice both during, and especially after, completion of the curriculum. The Department of Vehicle Engineering has extensive experience in the instruction of upper-level engineering subjects, but more limited experience in instructing first-year courses and in instructing computational and visualisation programs such as MATLAB. MATLAB is, however, a standard tool in both education and research at the department, so that a vast base of knowledge, on both the program itself and its application, is available there.

During the initial discussions within the group of instructors at the Department of Vehicle Engineering, we determined that it was essential to be able to offer students, with varying degrees of computer familiarity and programming ability, flexible instruction in MATLAB that makes efficient use of the time they have over from other basic subjects, such as mathematics. It was clear, before long, that a teacher-supported self-study course would ‘fit the bill’; in such a course, the students can obtain help from an instructor to an extent corresponding to their individual needs, while the instructors can, in turn, concentrate on those students who need help more than others. This, in turn, implies an efficient response to any specific learning difficulties that may arise. The concept of a self-study course in this context does not mean one in which the instructor resources are limited, but rather one in which the instructor resources are concentrated on those students that want and need additional support and help. The remaining students are offered, in such a system, greater freedom to pursue their studies at times and places that best suit them as individuals.

The project can be roughly divided into three separate phases:

- Preparations, above all an active search for suitable instructional materials and teaching methods, via Internet and through collegiate contacts.
- Trial instruction, with a limited number of student volunteers, in which different instructional materials, hypotheses, and methods shall be tested.

- First-year instruction, in which the objectives and methods should be verified by the help of a full-size class of students, taking the course as a requirement.

This paper describes how the project has been carried out, what results have been obtained, and finally, what experiences are relevant for the future of the course.

PREPARATIONS

An active search, especially via the Internet and through other contacts, demonstrated that a great deal of teaching material was readily available and provided the insight that we should not use our limited resources to create more of the same. A preliminary survey covered about 12 different selections of teaching material, of which 7 were chosen for further, more detailed consideration. The content of the 7 items selected is presented in Table 1.

To serve as a basis for the trial instruction, four of the items deemed suitable were selected. The criteria applied were:

- Sufficient scope; the MATLAB part of the course gives 1–1.5 credit points, where 1 point implies an effort equivalent to full-time studies of one week in duration.
- Content well-suited to the particular students, and to the Vehicle Engineering program in a broad sense.
- Sufficient diversity of arrangement and content amongst the various options.
- Anticipated availability of the material, as well as its cost to the students.

The four items selected for further evaluation in the context of the trial instruction were:

1. M-Tutor, a CD-based interactive course from the University of Saskatchewan, Canada. The material is written in English. Author: Brian Daku [11].
2. An Introductory MATLAB Course—with Engineering Applications, part 1. A compendium from the Linköping Institute of Technology, written in English. Authors: Niclas Bergman and Fredrik Gustafsson [18].
3. Matematik med MATLAB. A compendium from the Chalmers University of Technology, written in Swedish. Author: Carl-Henrik Fant [21].
4. An Introduction to MATLAB. A compendium from the University of Dundee, Scotland, written in English. Author: David F. Griffiths [22].

TRIAL INSTRUCTION

The overall objective of the trial instruction was to see how well the four selections of course material were suited to a teacher-supported

Table 1. Content of the preliminary selections for self-study materials on MATLAB. The materials were mainly found through the Internet and via contacts. The item 'Getting started with MATLAB' is supplied by the originators of the program itself, The MathWorks, Inc, USA. It is about 85 pages long and therefore a little too extensive for our purposes, but serves well as a reference. ✓ = the topic is treated; (✓) = the topic receives only a rather limited treatment.

	M-Tutor [11]	Linköping [18]	Praktisk matematik med MATLAB [19]	Getting started with MATLAB [20]	Chalmers [21]	Dundee [22]	Lund [23]
Using MATLAB:							
- starting MATLAB	✓	✓	✓	✓	✓	✓	✓
- workspace	✓	✓		✓	✓		✓
- command window	✓	✓	(✓)	✓	✓		
- help facilities	✓	✓		✓	✓	✓	✓
MATLAB variables:							
- defining variables	✓	✓	✓	✓	✓	✓	✓
- built-in variables	✓	✓	(✓)	✓	✓	✓	✓
- built-in functions	✓	✓	(✓)	✓	✓	✓	✓
- string variables		✓		✓	✓		✓
Scalar math:							
- defining a scalar	✓	✓	✓	✓	✓	✓	✓
- operators	✓	✓	(✓)	✓	✓	✓	✓
- scalar functions	✓	✓		✓	✓	✓	
Vector math:							
- defining a vector	✓		✓	✓	✓	✓	✓
- vector manipulation	✓			✓	✓	✓	✓
- expressions and functions	✓		✓		✓	✓	
Basic plotting:							
- basic line plotting	✓	✓		✓	✓	✓	✓
- plotting vector variables	✓	✓	✓	✓	✓	✓	✓
- line styles, markers	✓	✓		✓	✓	✓	
- axes box	✓	✓		✓	✓	✓	
- labelling	✓	✓		✓	✓	✓	
- multiple plots	✓	✓	✓	✓	✓	✓	✓
- logarithmic scale		(✓)		✓			
- hard copy		✓		✓		✓	✓
Relational & logical operators	✓	✓		(✓)	✓	✓	✓
Basic programming							
- flow control (if, for, . . .)	✓	✓		✓	✓	✓	✓
- m-file scripts	✓	✓	✓	✓	✓	✓	✓
- function m-files		✓	✓	✓	✓	✓	✓
Matrix math:							
- defining a matrix	✓	✓	(✓)	✓	✓	✓	✓
- indices	✓	✓		✓	✓	✓	✓
- matrix manipulation	✓	✓		✓	✓	✓	✓
- search & compare	✓	✓		✓	✓	✓	✓
- expressions & functions	✓	✓	✓	✓	✓		✓
- linear equation system	✓	✓	✓	✓	✓		✓
Advanced graphics:							
- 3D-plots		✓	✓	✓	(✓)	✓	
- contour plots		✓		✓		✓	
Complex variables			✓		✓	✓	✓
Language	English	English	Swed./Engl.	English	Swedish	English	Swedish

'self-study' course, and to work out an appropriate form of examination for the course. The more particular objective was, moreover, to try to arrive at answers to questions of the type:

- How well do self-studies work in this context?
- Is the flexibility afforded by self-studies appropriate at the beginning of a student's university studies?
- Does this form of instruction actually result in teacher resources being allocated to those who need assistance the most?
- Are the various instructional materials more or less well-suited to different learning patterns?
- Can it be determined to what extent prior computer and programming experience influences learning?

Table 2. Results of working test, indicated by the percentage of correct solutions and the average total time spent in each group working through the course material prior to the working test

Material	M-Tutor [11]	Linköping [18]	Chalmers [21]	Dundee [22]
Share of correct responses in test	75%	72%	66%	63%
Average time spent, hours	16.4	18.7	11.8	14.7

- Are there weaknesses in the proposed teaching model that can be identified and avoided?

The fundamental idea behind the trial instruction was to carry it out with student volunteers at the same stage in their curricula as the students who would be taking the course on an obligatory basis in the following academic year. For that reason, the trial instruction was scheduled to take place in the spring–winter of 2001. In total, 38 students applied to take part, of which 33 actually did take part from the beginning and of which 27 eventually fulfilled all of the tasks. The participants brought a questionnaire to the first meeting, the purpose of which was to survey their respective amounts of computer experience, whether they have access to a home computer, whether they frequently use the KTH computer facilities, what they typically use computers for, and any possible previous exposure to MATLAB. Some of the conclusions that can be drawn from the questionnaire are:

- Good average computer skills, about 6 years.
- More than 90% had access to a computer they could use at home.
- Wide range of computer usage.
- About 30% have, before their KTH studies, used computers for technical calculations.
- About 75% have never used MATLAB before.

At the initial meeting, the participants were divided into four groups with each assigned one of the four course material selections; the division was effected by a random drawing, with the provision that those who would work with M-Tutor had to have a suitable computer at home, and such that those with considerable computer background would be evenly distributed among the four groups. The students were informed of the objectives and purposes, and that they should now

work through the material during a two-week period and observe their own work carefully, especially with respect to the amount of time spent. After a few weeks, a review meeting would take place at which all would undergo an exam-like work test in front of a computer and take part in a discussion of the instruction material, methods, and forms of examination. The work was carried out with very few contacts between the participants and the instructors. Those contacts that were made were exclusively of a computer-technical nature. A week after the initial meeting, a work survey was e-mailed to the participants in which they were supposed to provide detailed answers about the instructional material, their work methods, how well they had learned, their time spent, any particular difficulties, etc. The questionnaire was turned in a few days before the final meeting with the working test and oral discussion.

At the working test, the participants had to sit alone at a computer for about 45 minutes and solve a number of short problems, as well as one somewhat larger programming problem. All individual activities were saved in a work file, and the instructor group could go in later to follow the course of the work in detail, and determine whether or not the task had been solved in a correct way. Table 2 summarises the average results for each of the four different groups, as well as how many hours they had spent, on average, working through their respective course materials.

The average test results vary from 75% for M-Tutor to 63% for the Dundee material. That range can probably even be assumed to correspond to the range for the student groups as such, since they only consisted of seven individuals on average.

After each group’s respective working test, a

Table 3. Summary of group discussions after the working test.

Question	Answer
Are you representative of an ordinary class of students?	The groups considered themselves representative. (It should nevertheless be noted that these students had taken upon themselves an extra task during the course of their regular studies.)
Is the form of instruction, with introductory lectures and computer sessions in which one can sit and work independently with the material and obtain assistance from a teacher as needed, appropriate?	Unequivocally yes.
How would you rate the idea of examining the course by answering questions and sending the answers to an instructor by e-mail?	No, better to be able to speak personally with an instructor and present one’s results.
Is it a suitable method of examination to come and, for about 20-30 minutes, making use of a computer, present a solution to a relatively complex programming task to the instructor that formulated that task?	Yes

discussion followed in which a number of follow-up questions were put forth. These questions and the answers they elicited are summarised in Table 3.

As further commentary to the evaluation of the various materials, it can be added that the four selections of working material have, in large part, not shown any great differences as far as the students' general assessment of them is concerned. It was nevertheless fairly obvious that M-Tutor and the Dundee-material were the most appreciated. For example, M-Tutor was the option that was most recommended to fellow students and got a good grade since both the text and the examples were easily understood. Moreover, it was easy to search for information and to get clues when stuck. It should nevertheless be noted that M-tutor has the disadvantage that one is left without any written material once the CD has been turned back in. The Dundee material was appreciated since it was considered to have a logical structure, to be easily understood, and to help the students to get an overview of MATLAB.

It has not been possible to discern any unequivocal difference in the effectiveness of the various selections of teaching resources, for different learning situations. It is nevertheless clear that the students themselves consider independent work as the best means to contribute to their own learning. Participation in study groups and laboratories comes next, in that order. The least is gained from lectures, while exercises are more highly regarded. Despite that, it is not considered self-evident that work with self-study resources is more effective than traditional teacher-led instruction. Clearly, however, the students, to a large extent, consider it important to learn to work independently in order to further their life-long learning.

The students using the Linköping material have, on-average, spent the most time working through the material—over 18 h. Those using the Chalmers material spent the least time at it—not quite 12 h. It is moreover evident that the students have primarily worked individually at their computers, and not in groups or even in pairs. The work was mainly carried out during daylight hours: 8 AM to 6 PM. A very clear phenomenon is that the students, in large part, valued the opportunity to work with the material at their own respective paces, and to be able to allocate the time needed to any specific aspect. The group that worked with M-Tutor indicated that they very rarely became stuck in the material, and none of the groups had, to any extent, sought or received help from their classmates.

The M-Tutor group had 75% right on the working test. The Linköping group had 72% right and the Chalmers and Dundee groups had 66% and 63% right respectively, on average. A review of the working files showed that none of those in the Dundee-group had used the help function built into MATLAB, even though it had been highly recommended. When questioned on that, the

group indicated that they had thought it was not permitted.

From the discussion following the working test, it became evident that, among other things:

- The students are positive towards learning MATLAB by means of self-study material, but it is appropriate to hold a number of introductory lectures and a teacher-led computer session for those that wish to attend.
- The students completely reject an 'automated' form of examination in which solved problems are to be submitted by e-mail; they very clearly prefer the chance to present a solution to an engineering-based programming problem directly to an engineering instructor.

On the basis of the student's working test, the results of the questionnaire, oral discussions, and the form and availability of the materials, the CD-based M-Tutor and the compendium from the University of Dundee were selected as the two alternative instructional materials to use in the coming course.

The main reasons for choosing M-Tutor were:

- The students' positive opinion towards it.
- The material is forgiving with respect to prior computer and programming experience.
- The good results on the working test.
- One of the resources selected should be interactive and CD-based.
- The author, Brian Daku, was accommodating about adding some supplementary material that we had proposed.

In a similar way, the main reasons for selecting the Dundee material were:

- The students' positive opinion of it.
- The material is easily obtained through the Internet.
- Except for the printing alone, it costs the students nothing.
- The author, D. F. Griffith, was accommodating about adding some supplementary material that we had proposed.

Evaluation of programming task. As was made clear in the preceding, the idea of examining the MATLAB section by way of an oral test, with the help of a computer-reported programming task, won strong support. The trial instruction was extended for that reason by such a programming task. The students who had been participating earlier were asked if they would be interested in taking part. Four students signed up. That so few showed interest in taking part again, can be partially explained by the workload of the students in question at the end of the academic year. The thought was, moreover, that besides the programming task and the examination portion, the newly added element would give additional positive contacts with the teaching staff and an early perspective on their studies to come. It was anticipated that the instructor who formulated the problem task would even serve as the 'examiner'.

We envisioned the students signing up for the examination and getting 20 to 30 minutes with their ‘examiner’ at the computer to explain how the solution is structured and what the results of the problem can look like, and even to demonstrate that they can make changes in their respective programs and carry on a discussion of the solution and of the engineering issue at hand. With this additional element, we want to give additional focus to the chain from a primarily mechanical problem to a technically applicable solution. We want to get the students thinking in an ‘engineering’ fashion and making use of their programs to seek a solution for the problem at hand. Since the students, at that early stage in their studies, have yet to attain basic skills to a sufficient extent, all mathematics, mechanics, and numerical relations must be given, together with a suitable analytical approach. This element of the course will offer the chance to look forward to later courses and thereby even give an early perspective on their studies to come. The description of the task will be a resource with its own inherent value, insofar as it will describe a well-defined mechanics problem, will relate physical reality to a mathematical model, present a suitable analytical approach, and make reference to coming courses.

Despite the paucity of participants, experience from the evaluation shows that a programming task in the form of a readily applied engineering problem can be a well-appreciated and useful form of examination. To facilitate the solution of the task for those students with less programming and problem solving background, it should be formulated as a step-by-step methodology and furnished a proposed analytical approach. Moreover, relatively liberal access to instructor assistance is to be provided. To give the most ambitious students sufficient stimulation, the basic obligatory task should also be accompanied by a voluntary, more difficult, extra credit portion. Of the four students that undertook the task, three provided a satisfactory solution, while the fourth was unable to present a solution.

FIRST YEAR OF REGULAR INSTRUCTION

As was stated above, the MATLAB section is one part of a larger course, ‘Perspectives of

Vehicle Engineering’, which is given to first-year students of the Vehicle Engineering program at KTH. The MATLAB course is presented as a teacher-supported self-study course. The students will, as such, go through the material on their own, with the help of 4-h lectures and 24-h computational sessions. The course is concluded by an individual examination. In total 120 students undertook the MATLAB course during the spring semester 2002. Figure 1 shows the time planning of the course.

The students could choose as the primary study material either of the two alternatives: the Dundee compendium ‘An Introduction to MATLAB’ by D. F. Griffiths [22], or the interactive CD-based ‘M-Tutor, An Introduction to MATLAB’ by Brian Daku [11]. The CD-based material was recommended as suitable for those students that would prefer a more directed reading and an active guidance through the material. To complement these two resources, a collection of example problems [24] was produced.

Both 2-hour lectures were essentially introductions to the area and material. They were both well attended. The 2-hour computer sessions, totalling 24 hours, had only 5 to 10 students attending at the beginning. After the examination task was distributed, the number attending increased strongly, so that there was even a shortage of places at the end. Besides the lectures and computer sessions, it was also possible to obtain individual assistance from the instructors, an opportunity of which only 10 of the students availed themselves.

The examination was carried out in the form of individual presentations of project tasks. In total, we had 10 ready tasks at our disposal; these were distributed randomly amongst the students. All of the tasks came from areas of relevance to vehicle engineering, and were realistic engineering problems. The description of the programming tasks was relatively extensive, about 5 A4 pages, and consisted of 4 parts: an introduction; a methodology and model description; a description of the analysis and execution; and, finally, a part in which the examination’s demands are stated. The introduction also gave a short description of the relevance of the problem to vehicle engineering. The method and model description gave an overview of the models and methods that can be used to solve the problem. Since most of these methods

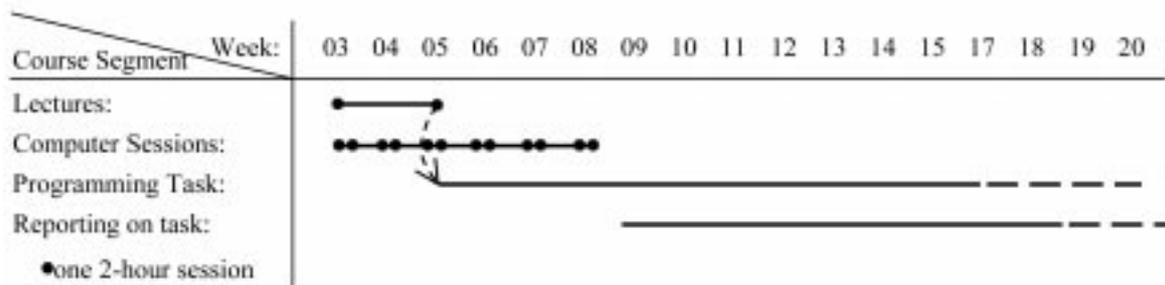


Fig. 1. Time plan of the MATLAB course.

are not familiar to first-year students, even that part contains an early perspective in which we hint at the content of later courses in the various subject areas.

Another thought behind this part is to train the students to identify and understand problem definitions presented in larger continuous blocks of text. The description of analysis and execution contains a short overview of the steps that should be included in the solution of the problem. Finally, a proposal was made for a voluntary extra credit task. A satisfactory solution of that extra task gave bonus points that could raise the final grade in the course. The extra credit task was connected to the obligatory task and usually involved creating a graphic user interface (GUI). The students were also given the opportunity to, under the advice of their respective advisors, formulate their own extra credit tasks. The solutions to the respective tasks were reported by each student individually to an advisor. On that occasion, the advisor ensures that the student has detailed knowledge of the solution by placing questions and requesting modifications and improvements of the code. At the individual reporting session, the student is requested to show their solution of the task, go through its various parts, and carry out changes as proposed by the advisor. That is to ensure that the student has detailed knowledge of the structure of the solution. Every such reporting session took about 20 minutes.

Of about 120 students that received the programming task, 89 of them, i.e., about 75%, were passed on September 1, 2002; of these, however, only 4 students, i.e., 5% of them, carried out the voluntary extra credit task.

Course evaluation

The course was evaluated, partly with the help of a student questionnaire that was turned in on the same occasion as the programming tasks were reported on, and partly with the help of interviews in connection with the report. At the end of the spring term, 77 questionnaires had been turned in.

The evaluation of the questionnaires can be summarised as follows, in general:

- 69% of the course participants had 6–11 years of regular computer experience.
- 5% regarded themselves as having extensive programming experience.
- 83% regarded the obligatory Java-programming course as their only experience within the subject area.

Only a small percentage indicated any prior experience with MATLAB. Regarding course material:

- 78% of the students had used the Dundee material, 6.5% had used M-Tutor, and the remaining 15.5% indicated that they used both resources.
- Of those that used the Dundee material, 79% stated that they were satisfied with the material. The corresponding figure for M-Tutor was 70%.

- Of those who provided viewpoints on the example collection, 75% were positive and 69% indicated that it was sufficiently well-adapted to their respective knowledge levels.

Lectures and computer sessions:

- 83% of the students took part in both lectures, of which 73% were, however, unsatisfied with what they got out of it.
- 66% took part in a computer session and of these, 61% thought the return on their time was good.

Programming task:

- 95% felt that the form of examination, a programming task was good, and that the oral accounting of the task is better than a traditional written form of examination.
- 93% appreciated that, within the framework of the programming task, they could work on an engineering problem.
- 65% indicated that they had experienced difficulties understanding the problem.
- 65% indicated that they didn't encounter mathematical difficulties.
- 62% stated that they essentially solved the task on their own.

The time needed to solve the problem varied a great deal. Typical was about 10 h, and 86% indicated a time between 3 and 25 h.

Regarding, the entire MATLAB-section, the structure of an instructor-supported self-study course was regarded by 56% as positive overall, while 43% leaned towards a negative opinion. However:

- 70% indicated that they found this section of the course to be meaningful.
- 90% believe that their MATLAB knowledge will be useful during their coming studies.
- 70% believe that their MATLAB knowledge will be useful during their coming careers.

The instructors' experiences and conclusions after the first year's activities are summarised below. An important observation is that the students did not make use of the interactive CD-based M-Tutor to anywhere near the extent expected. From the answers to the questionnaire, it can be seen that, for the most part, they chose to work with the Dundee compendium. Of those that chose to work with the Dundee material, 40% found it to be the most convenient, since it was available in the course pack, and 29% said that they wanted to have compendium material in which they could establish the pace by themselves, as well as the sequence of material covered. 8% of the students indicated that they chose M-Tutor, since they wanted to have an interactive learning aid that would guide them through the material. Another experience is that many students undertook the programming task before they had acquired fundamental MATLAB knowledge to a sufficient extent. The reason for that is probably that they

Table 4. Some key figures for students

Activity	Number of questionnaires considered	Number of years of regular computer usage	Access to a computer for use at home, %	Earlier MATLAB experience, %
Trial instruction	33	6.2	93	24
First year of instruction	77	6.7	82	4

wanted to get underway with the work leading up to the examination as soon as possible, which is of course logical, but which can also lead to inefficiency in their self-study work insofar as the logical structure afforded by good pedagogical materials is foregone. That latter effect is probably also one of the reasons they would choose the Dundee material. It is possible to read through a compendium quickly, in contrast to an interactive CD-based study aid, which more or less requires one to follow a specific sequence. Another observation is that many of the students seem to have gotten their work off to a slow start. There can, naturally, be several reasons for that; one is that when a course is dependent on the individual student's own planning, higher priority might initially be given to other courses, and other parts of the same course, with a more directed structure. For most of them, however, it is probable that this is a problem related to their transition from secondary to university-level studies. Yet another important observation is the difficulty that many students seem to have, in the beginning of their university studies, to read, understand and transform a large-scale assignment description into a concrete plan of action.

On the basis of the responses to the questionnaire, the instructors even tried to determine whether there was any connection between prior computer experience and the ability to solve the programming task. No such connection was evident, however. On the contrary, our experience was that the success and quality of the solution was primarily dependent on the amount of time that was allocated to the work.

With regard to the course on the following year, we decided to continue providing both self-study materials, the Dundee compendium, and the

CD-based M-Tutor. The first year's course showed that the collection of example problems should include more examples of engineering problems with relatively detailed definitions, and solutions for all examples. A list of recommended exercises will be given in the beginning of the course. The lectures should contain more examples with focus on problem solving and programming. Shortly after the examination task is distributed, students should have a short meeting with their respective advisors to go through the assignment description. This would help students to understand the problem and get started with programming easier.

CONCLUSIONS

The project was initiated by a trial instruction for 30 student volunteers and followed up by an obligatory course activity for about 120 students. Some of the key figures are collected into Table 4.

The number of years of regular computer experience is more or less even, as is the access to a computer for use at home. That which differs markedly is that the students in the trial instruction had more prior experience using MATLAB. That, together with the fact that the students in the trial instruction voluntarily took on more work alongside their ordinary coursework, can go a long way towards explaining the discrepancies in results that have arisen.

We can see that, in the trial instruction, M-Tutor stood out as somewhat more attractive than the Dundee material. In the first year of instruction, on the other hand, an overwhelming majority of the students chose to work with the Dundee material; see Fig. 2. The reason for that choice is

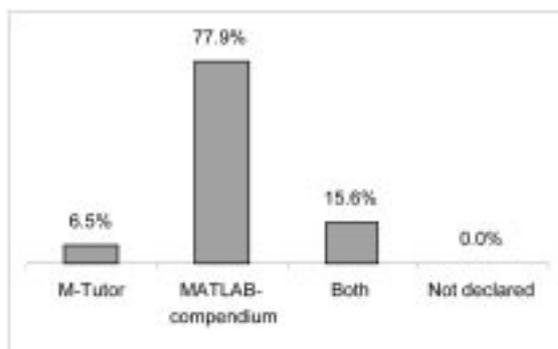


Fig. 2. The students' choice of instructional material in the first year course.



Fig. 3. Main reason for the choice of course material in the first year course.

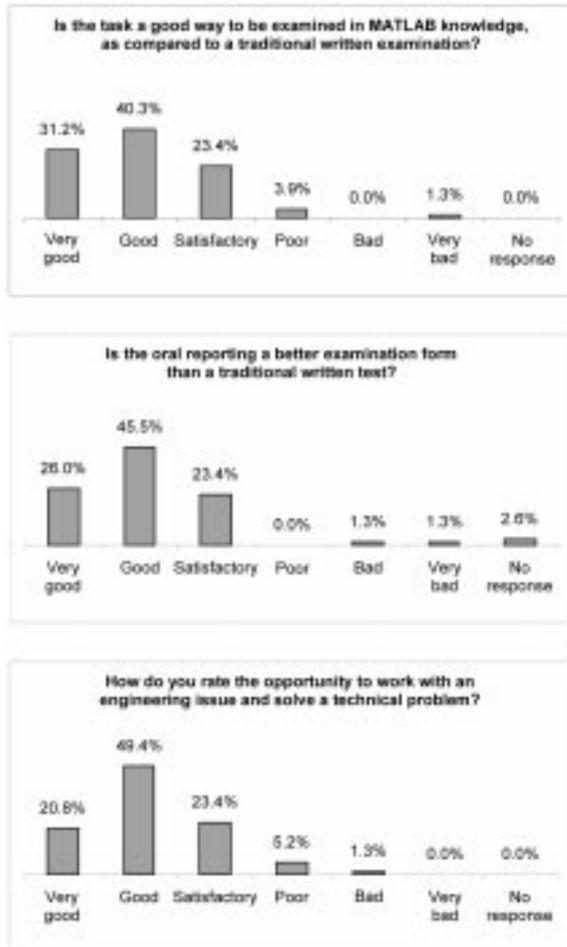


Fig. 4. The students' opinion of the examination form in the first year course.

seen in Fig. 3. Moreover, there is surely also the effect that M-Tutor takes longer to work through whereas a conventional compendium offers the chance to quickly read through material until one finds something particular being sought, and is also better suited as reference material.

Thus, the overall lesson is that the experiences and conclusions drawn from a trial instruction of student volunteers can differ tangibly from the experiences that are obtained from a required course.

That the form of examination was well regarded

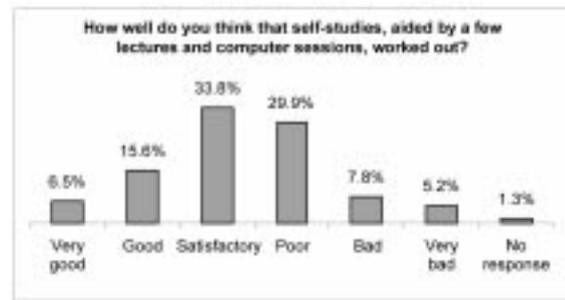


Fig. 5. The students' opinion of the course format for the first year course.

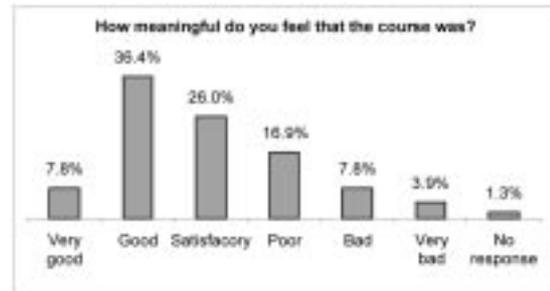


Fig. 6. The students' opinion of the MATLAB course in the first year of instruction.

is clear from the results in Fig. 4. It is not obvious that the instruction should be in the form of a self-study course, see Fig. 5. Even though the majority of the students are positive to the form of instruction, there remain 43% that lean towards a negative opinion. On the other hand, that the course was regarded as meaningful and that the students are convinced of the usefulness of the activity, is evident from Fig. 6.

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