Comparative Analysis of Learning Approaches in a Course on Decision Analysis

Mat-2.108 Independent Research Project in Applied Mathematics

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1 Introduction

The Systems Analysis Laboratory (SAL) at the Helsinki University of Technology participated in the European Union funded OR-World project\(^1\), whose objective was to develop on-line learning material to the World Wide Web. Within the project SAL produced learning material on negotiation analysis, multiple criteria decision analysis, group decisions and decision making under uncertainty\(^2\). The slides on decision making under uncertainty, which were made by the author, have been fully utilised in the HUT course in decision analysis called “Mat-2.134 Decision-making and problem-solving”, whereas the rest has mainly been used as additional material. During this project, a need for an evaluation tool for assessing the appropriateness and usefulness of this e-learning material has emerged. Without any evaluations one could spend considerable amounts of human and monetary resources on web sites whose usability is questionable. The motivation behind this research study was to meet this need.

In this study, an evaluation tool for the course in decision analysis was designed. Because the course was not solely a web course, but used only the web as an additional tool, the evaluation could not fully focus on e-learning. Instead, the evaluation was focused on finding out which learning events and materials the students used for learning different topics in decision making and what materials they would want to use. The goal was to identify which topics are suited for e-learning and which are not. Another objective of the evaluation was to measure the students’ level of knowledge regarding different topics. This gave an indication of how well the learning events worked as a whole and if the educational goals of the course were met. Furthermore, feedback about the new lecture slides was gathered. To keep the workload reasonable, the evaluation was limited to the second part of the course dealing with decision making under uncertainty.

\(^1\) http://www.or-world.com/, referred 28.08.2003.

Section 2 introduces some evaluation theories and knowledge hierarchy definitions. Section 3 presents the evaluation methods used and section 4 the results. The work concludes with a discussion about the methods and results in section 5.

The work was done in the Systems Analysis Laboratory at Helsinki University of Technology under supervision of Prof. Ahti Salo.

2 Evaluation Theories

Course evaluation is done to assess whether the course fulfils its educational and financial goals, to compare different learning methods and to aid the development and improvement process. There are several models for evaluation of which the one by Kirkpatrick (Carliner, Clark 1997, Jolliffe et al. 2001, Owston 1999, Winfrey) is perhaps the most known. In the following section the main ideas behind the model will be enlightened.

2.1 Kirkpatrick’s Four Levels of Evaluation

In 1975 Donald L. Kirkpatrick presented his four-level model for evaluation of education. It is a thorough and general method that incorporates all major aspects of evaluation of training programs. The four levels are reactions, learning, transfer and results (see Figure 1).

![Figure 1 Kirkpatrick's four levels of evaluation (Winfrey).](image)

According to the model, evaluation should always start at level 1 and succeed sequentially to the upper levels whenever appropriate, keeping budget and time constraints in mind. The results of each prior level serves as a basis for the next
evaluation level. Thus, each level gives a deeper picture of the training program, but requires also more rigorous and time-consuming analysis.

One shortcoming of this model, however, is that it does not deal with the goals and values of the provider of the training program. Every provider is certainly at least somewhat concerned with cost efficiency, but especially universities are also interested in the all-round education of the students and in the image of the university.

2.1.1 Level 1: Reactions

The first level deals with the reactions of the participants. The evaluation is typically carried out using a questionnaire. Groups giving qualitative feedback can also be used. The questions addressed at this level are e.g. the feelings of the learners about the appropriateness of the course, the standard of the learning material and the methods used.

Satisfaction of the participant is important, although it does not imply reaching the learning objectives. However, satisfied participants are more likely to learn than unsatisfied ones.

2.1.2 Level 2: Learning

At the second level the development of the skills, the gain of the knowledge and the change of the attitudes is assessed. In other words, one wants to find out if the participants have learned anything. The assessment is usually done by a test right after the course, possibly supplemented with tests during the course. The questions are designed to measure how well the learning objectives are met. To validate the results of the post-test, a pre-test may be carried out to differentiate between prior knowledge and the learning occurring during the course. Information about the knowledge level of the learners can also be received by observation, interviews and surveys.

Evaluation at this level indicates whether the learning is efficient or not, but does not necessarily tell how well the participants are able to use their new knowledge in their normal working environment.
2.1.3 Level 3: Transfer

The third level measures how the received knowledge, skills and changed attitudes are transferred from the learning environment to the every day working environment of the participant. Although he would have learned, the use of the new resources at the working place is not evident. In this case, his organisation does not benefit from the course.

The transfer level of the evaluation cannot naturally be carried out during the course, but rather in the own environment of the participant. An appropriate time for the evaluation is normally from 6 weeks to 6 months after the learning event. The changes are assessed through tests, observations, surveys and interviews with co-workers and supervisors. This level can be considered as a follow-on assessment of quality.

2.1.4 Level 4: Results

Often referred to as the bottom line, the fourth level assesses the success of the learning program from the organisational point of view. This is done financially by measuring such quantities as increased production, improved quality, decreased costs, increased sales or higher profits or return to investment. From an organisational perspective, this is the overall reason for the training.

Table 1 Means of evaluation at different levels (Jolliffe et al. 2001).

| Level 1     | Questionnaires   |
|            | Discussion groups |
|            | Direct feedback  |
| Level 2    | (Pre-/post-) testing |
|            | Observations    |
|            | Interviews      |
|            | Surveys         |
| Level 3    | Tests           |
It is difficult to isolate the results of a training program and observed improvements are hard to link directly with the training. While training probably has some effect on the results, also changes in personnel, systems and other factors contribute to business performance. These problems are the main reasons why evaluation at this level is usually not done. Table 1 summarises the ways in which evaluation on the different levels may be done.

### 2.1.5 How Levels Fit in University Course Evaluation

The four-level framework is primarily designed for companies or organisations whose employees participate in training sessions. After taking a course, the employee returns to his work and applies acquired skills. University students cannot be directly compared with employees and therefore, the different levels and their interpretations are not directly applicable to the evaluation of university courses. The interpretations of levels 1 and 2 are suitable also for university courses, but levels 3 and 4 are more difficult to adapt.

The transferred knowledge in level 3 could refer to how students are able to use their skills at their future work. This would, however, mean that the evaluation could usually not take place before the graduation of the students. Depending on the course, there may be several years between taking a course and graduating. This is not only awkward because of the delay of the evaluation process, but also makes it much more difficult: During the interval time the student has most likely acquired supplementary skills and knowledge. Thus, it is very hard to link the achievements at work to a certain course.

Another interpretation could be deliberating how useful the gained knowledge is on other courses. This could, however, imply that an introduction course is very useful,
whereas an advanced course, representing the state-of-the-art in the field, is useless. Maybe the most suitable interpretation would be to judge how well the course fits into the student's overall study plan and how it promotes his level of all-round education.

If one wants to carry out a fourth level evaluation of a university course, the organisation must first be defined. In most cases there is no organisation sending students to certain courses. Of course, the university determines the compulsory, optional and recommended courses, but it is not easy to define how the faculty or university benefits from a student's participation. Like in level 3, one could also think of the future employer of the student as the organisation. In that case one runs into the same problems at level 3: there is too much time between the course and the evaluation. As people change work assignments or work places quite often, it may well be that the former student has no use of a certain skill in one working place, but finds the same skill very useful in another.

2.2 Evaluating Web Courses

When evaluating on-line learning material, there are some additional ways to receive data compared to the ones listed in Table 1. The on-line environment makes it easy to manage questionnaires with questionnaire and voting software such as Opinions-Online\(^3\). Another benefit of the new technology is the special programs that follow the actions of each user of the learning web sites and stores all the data in log-files\(^4\).

The web analytics software is especially useful for validating the results of level 1 questionnaires and oral feedback. It has been shown (Owston 1999, Blumstengel et al. 1999) that questionnaire results are often inaccurate. Many people report that they have spent more time on the web sites than the log-files show. Some people even have distinguished opinions and claim they have used web pages they never visited! Web analytics software might give you a more realistic picture of the degree of utilisation of your on-line learning material. But of course these programs cannot observe off-line usage of the pages; people may download and save the pages to their own computers or print out pages for reading.

2.3 Levels of Knowledge

In Kirkpatrick's model, levels 2–4 deal with the learning of the participants and the application of their knowledge in real situations. Another way of looking at knowledge is to divide it into different levels according to its human, intellectual processing (Suurla et al. 2002). According to this division, the higher the processing level, the more human thinking, intellectual manipulation and assessment the knowledge contains and the less it can be processed or produced in the form of technically detached material.

Figure 2 Knowledge hierarchy (Suurla et al. 2002).

Figure 2 shows a common knowledge hierarchy. The following definitions are adapted from Suurla et al. (2002):

Data refers to codes, signs and signals that may not have any significance as such, but merely serve as knowledge raw material.

Information consists of data with a meaning or interpretation. Through human processing it can be transformed/changed into knowledge.

Knowledge is gained by learning and adopting. Information does not become knowledge until the learner has thought it carefully through and made it an integral part of his personal knowledge. Because knowledge requires personal processing, it is always context-bound. Separating it from the context makes it just information.

Through experience knowledge becomes understanding. People associate understanding with various explanations why things are as they are and how they relate to other issues.

*Wisdom* refers to metacognition, which people use to create new knowledge with their previous knowledge, experience and understanding as the basis. Wisdom is also associated with quality of life and exploitation of knowledge for good causes.

Another hierarchy model is presented in table 2.

**Table 2 Another knowledge hierarchy (Suurla et al. 2002).**

<table>
<thead>
<tr>
<th>Level of Knowledge</th>
<th>Which questions does it answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information</td>
<td>Simple, fragmented knowledge that answers the questions: What? Where? How many? When?</td>
</tr>
<tr>
<td>Skill</td>
<td>How to carry out the task at hand?</td>
</tr>
<tr>
<td>Explanation</td>
<td>Why? What is behind the phenomenon? How does an issue affect other issues?</td>
</tr>
<tr>
<td>Understanding</td>
<td>What are the underlying motives? What is the structure like? What does the structure analyse?</td>
</tr>
</tbody>
</table>

3 Evaluation of the HUT Course in Decisions Analysis

3.1 Course Description

The Systems Analysis Laboratory at Helsinki University of Technology (HUT) offers an introductory course in decision analysis called “Mat-2.134 Decision-making and problem-solving”. Its main topics are value tree analysis, decision making under uncertainty and group decision making. The 2-credit course requires no prior knowledge in decision analysis, but the basics in mathematics and probability theory
are expected. The target group is third and fourth year undergraduate students, with a major or minor in operations research. The course is available for all students at HUT.

The course is taught through in-class lessons and training sessions. The decisions analysis e-learning material produced at SAL was used as complementing material on the course in autumn 2002. The different learning events and sources of information on the 2002 course were:

- Lectures
- Training sessions
- Course web page containing:
  - Lecture slides
  - Training session and home assignment questions
  - Links to SAL’s e-learning site containing theory sections, demos, quizzes, video clips etc.
  - Links to other e-learning sites
- Course handouts containing copies of the lecture slides, answers to training session questions and some additional readings delivered through the university copying service (EDITA).
- Course book: Clemen: *Making Hard Decisions*
- Home assignments

### 3.2 Evaluation of the Course

An evaluation of the course in decision analysis was done within this independent research project. To keep the workload reasonable, the evaluation was focused on the second part of the course dealing with decision making under uncertainty. Seen from the Kirkpatrick’s model’s point of view, the evaluation was restricted to the first and second level, reactions and learning.

The aim of the evaluation was to find out which learning events the students found most useful for learning different topics and to measure their knowledge at the different levels of the knowledge hierarchy. The goal was to identify the topics that
were most suitable for e-learning. The students were also asked to give feedback about the new lecture slides.

The knowledge was evaluated in a home assignment with questions designed to measure knowledge at different hierarchy levels. The other issues were evaluated through an on-line questionnaire using the Opinions-Online® software. It was expected that the easier topics would be more suitable for e-learning than the harder ones and that the way in which people learn differ from topic to topic according to the characteristics of topics.

3.2.1 Home Assignment

The home assignment contained four problems, focused on different hierarchy levels of knowledge according to the model in Table 2. The assignment questions can be found in the appendix. The first problem, asking the students to briefly explain the meaning of six basic concepts, assessed the students’ strength in information level knowledge. The concept were:

- Subjective probability
- Probability assessment using the histogram method
- Representativeness bias
- Second order stochastic dominance
- Value at risk

In the second problem, the students were asked to apply different decision rules to the problem of how many copies of newspaper one should buy to a newsstand, given the probability distribution of the demand. This problem required not just information, but also skill (see Table 2, page 10). In the third problem, the students had to answer questions regarding the purchase of a computer. Using a decision tree, the students decided whether to buy a new PC or an old one and whether or not to take the old PC to a store for valuation. To solve the problem the students had first to calculate the needed probabilities by using basic probability rules, such as the Bayes’ rule. Finally, some sensitivity analysis was made. This problem required yet a higher level of knowledge than the previous problems. In the last problem, the students were asked to explain how calibration of expert judgements could be done using a set of prior
judgements with known outcomes. The process was demonstrated using imaginary data that the students had to make up themselves. This problem was meant to require the highest level of knowledge of all the problems.

### 3.2.2 Questionnaire

The questionnaire had 4 sections. In the first section some basic data about the students was gathered, e.g. department, years of study. The students were also asked to assess their level of activity (participation in class, reading the course book etc.).

In the second section, the students were asked to tell how much different learning events contributed to their learning of some specific topics and what the optimal combination of learning events would be. The topics were:

- Estimation of probabilities
- Heuristics and biases in probability estimation
- Decision criteria
- Utility function and risk attitudes
- Decision tree analysis

For each topic the students first assessed their own level of knowledge on a scale from 1 to 5. Then they ranked different learning events in regard to how much the events had contributed to their learning of the topic in question. This was done by giving a number between 1 and 5 to each learning event, 1 being “not important at all” and 5 being “very important”. The learning events were:

- Lectures
- Training sessions
- Home assignment
- Lecture slides
- Answers to training session questions
- Course book
When assessing the events regarding learning heuristics and biases, the students evaluated also the usefulness of an on-line tutorial on Bayesian Nets and Probability\(^5\) with a section on heuristics and biases. The students gave also their view on the most suitable way to learn these topics by giving points from 1 to 5 to each learning event.

Next, the students were asked what topics they thought would be well or badly suited for e-learning. Finally, some questions about the new lecture slides were posed. The new slides were made in the PowerPoint format, in contrary to the past ones, which were written in Word. The content was improved as well as the visual layout. Due to the linkage to the OR-World project, the slides were in English, not in Finnish as the old ones. An example of the new slides can be seen in Figure 3. There were also several possibilities to give free comments about the topics in the questionnaire.

\[\begin{align*}
\text{Mode criterion} \\
\text{Problem:} & \text{The recommendation may depend on how the problem is structured:} \\
& \begin{bmatrix}
\theta_1 & 2/9 & 5 & 3 \\
\theta_2 & 3/9 & 5 & 3 \\
\theta_3 & 4/9 & 8 & 9 \\
\end{bmatrix}
\end{align*}\]

Alternative \(a_1\) is chosen.
Yet the two representations are equivalent!

4 Results

4.1 Home Assignment

The results from the home assignment, presented in Table 3 and Figure 4, show that the knowledge of practically all students was at least on the information level: all who

\(^5\) [http://www.dcs.qmul.ac.uk/~norman/BBNs/BBNs.htm](http://www.dcs.qmul.ac.uk/~norman/BBNs/BBNs.htm), referred 07.08.2003. The site was linked from the course home page.
answered the first problem had described most of the concepts right. Only one of the students had left the problem unanswered. The second problem went also well: almost all students solved it correctly. The third problem was a bit trickier, but still the average points were 3.04 out of 4. Many students had, however, problems with the last problem. The average points were just 1.67 out of 3. It was expected that this problem would be the toughest, because it was designed to require the highest level of knowledge of all the problems. It can, however, be seen from the questionnaire, that some students did not feel that the information about the topic in the learning materials was comprehensive enough. On the basis of the home assignment, it can be stated that the knowledge level lies for most students somewhere between skill and understanding, in most cases probably explanation.

Table 3 Results of the home assignment.

<table>
<thead>
<tr>
<th>Problem</th>
<th>Knowledge level</th>
<th>Mean / max points</th>
<th>Percent</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Information</td>
<td>0.9787 / 1</td>
<td>97.87 %</td>
<td>0.1459</td>
</tr>
<tr>
<td>2</td>
<td>Skill</td>
<td>1.8511 / 2</td>
<td>92.55 %</td>
<td>0.3599</td>
</tr>
<tr>
<td>3</td>
<td>Skill – Explanation</td>
<td>3.0426 / 4</td>
<td>76.06 %</td>
<td>1.1413</td>
</tr>
<tr>
<td>4</td>
<td>Explanation – Understanding</td>
<td>1.6702 / 3</td>
<td>55.67 %</td>
<td>1.6702</td>
</tr>
</tbody>
</table>

Figure 4 Mean and standard deviation of the students' points in the four home assignment problems.
4.2 Questionnaire

Here we summarise the most interesting parts of the results of the questionnaire. The complete results and the questionnaire form can be received from the author upon request.

4.2.1 General Information

Most of the students in the course in decision analysis studied at the Department of engineering physics and mathematics (34.7 %) or the Department of industrial engineering and management (42.9 %) and 95.9 % of the students were at least on their third year of study (see Figure 5). Almost 80 % of the students had operations research as their major (28.6 %) or minor (51.0 %).

![Figure 5 Distribution of the students in means of years of study.](image)

The lectures were popular: 52 % of the students attained at least one lecture out of two (Figure 6). The corresponding number for the training sessions was only 30 % (Figure 7). This may be seen as a statement that the lecturer had essential further knowledge and insight to offer, whereas the content of the training sessions could also be learnt independently, using the course home page and the copied course handouts as reference. The time of the training sessions may also have been inconvenient for the students.
Figure 6 Participation in class.

Figure 7 Participation in training sessions.

4.2.2 The Importance of Different Learning Events and Sources of Information

As described in section 3.2.2, the students were asked to assess their knowledge and rank different learning events and sources of information regarding five subtopics of decision making under uncertainty. The event ranking was done both regarding their actual learning methods and the ideal situation.
The students had about the same conception of the level of their knowledge as the home assignment suggested. On a scale from 1 to 5, the mean was between 3.1 and 3.7 for all topics and the standard deviation between 0.75 and 0.99 (see Figure 8). Not surprisingly the students felt their knowledge was poorest regarding the utility function and risk attitudes and strongest regarding decision tree analysis. Although the utility function is well defined, it is still quite complex a concept and may be tricky to understand. On the other hand, building and solving decision trees is quite straightforward and was practised thoroughly both during the lectures and in training sessions.
Decision tree analysis

Figure 8 The students’ perception of their knowledge level on a scale from 1 to 5.

The ranking of the different learning events turned out to be too a massive and time-consuming task according to the free comments in the questionnaire. This decreased the quality of the answers when the students did not bother to think carefully through all of the questions. As an example, the students thought the course book was at least somewhat important for learning the topics although a vast majority of the students had not read the book at all or only glanced through it. Nevertheless, some interesting patterns may be found from the answers presented in Figure 9 and Figure 10.

It was expected that the way in which people learn differ from topic to topic according to the characteristics of topics. The results do not, with some exceptions, support the hypothesis. The general result seems to be that all topics can be learnt using the same sources of information, i.e. one learning event is equally useful for all the topics. The differences in the results regarding the students’ actual learning experiences from the course are probably more consequences of the practical arrangements of the course, than of differences in the characteristics of the topics.

There were two training sessions in which constructing and solving decision trees was exercised. In addition, a decision tree problem was present in the home assignment. The effect of these exercises can be seen as significantly high bars at the corresponding places in Figure 9. The importance of the home assignment for the learning of estimation of probabilities and decision criteria is obvious due to exercise problems on the topics in the assignment. Heuristics and biases as well as the utility function and risk attitudes, on the other hand, played a minor role in the assignment. The same pattern, however not as distinct, regarding the home assignment can also be seen in the results in Figure 10 concerning the students’ opinions about the ideal way to learn about the topics. This suggests that problems concerning heuristics and biases and the utility function and risk attitudes are not equally well suited in home
assignments as the other topics. This makes sense at least for the heuristics and biases, for which it is hard to make meaningful assignment problems.

**Figure 9** Different learning events' contribution to the students’ learning of different topics.

Some interesting results can also be found when comparing the overall usefulness of different learning events. The lecture slides were clearly important in the learning process as well as the home assignment for those topics that were thoroughly addressed in the assignment. The course book, on the other hand, had the least importance. This conclusion is supported by the fact that 39% of the students reported
that they had not read the book at all and another 39% had only glanced through it. The lectures were found to be more important than the training sessions.

In the case of the ideal way of learning (Figure 10), the differences between the learning events are not significant. Encouraging for the developers of e-learning material, the not further specified “other e-learning material” was judged to have equally good potential as a course book.

4.2.3 Topics Well or Badly Suited for E-learning.

One of the main objectives of the evaluation was to identify topics that were especially well or badly suited for e-learning. The extensive set of grading questions whose results are summarised in Figure 10 did not shed much light on this subject. The questions with free answers gave, however, more information. In connection with the already discussed grading questions, the students were also asked what kind of additional e-learning material they would desire. The answers showed that they wanted more examples and case studies. Also an interactive bias test was requested.

According to the free answer questions, material well suited for e-learning can be summarised as follows:

- Material meant to be printed for reading. In this case the web is merely a distribution channel. This category includes e.g. lecture slides, training session questions and answers and additional case studies and examples.

- Interactive material, such as quizzes or tests regarding e.g. heuristics and biases, decision making software applications (e.g. Bayesian nets) and applets with solved numeric problems in which the numeric input values can be easily changed.

- Multimedia material. This includes e.g. video clips and other animations.

Some students thought that actually no topics are suited for e-learning or that the web does not contribute in any way to the learning process. Others pointed out specific kinds of topics that are not suited for e-learning. These were theory, axioms, proofs and other mathematically demanding or difficult topics.
4.2.4 Lecture Slides

The questionnaire included also a further evaluation of the lecture slides. As already mentioned, the lecture slides were seen important and got mainly positive feedback. At the time when the students answered to the questionnaire, which was around the time of the first exam held, most of them had spent several hours reading the lecture slides whereas 78% had not read the course book at all or only glanced through it (see Figure 11). The slides were available on-line on the course web page for scrolling and printing. However, only 30% printed the slides, because they were also included in the course handouts (Figure 12).

![Pie chart showing the amount of hours students spent reading lecture slides and their reading efforts of the course book](image)

(a) (b)

Figure 11 The amount of hours the students have spent reading the lecture slides Uncertainty and Risk 1 and 2 (a) and their reading efforts about the same topics from the course book (b).
Figure 12 Answers to the question “In what way did you acquire the lecture slides?”. The students were asked to assess on a scale from 1 to 5 (1: I totally disagree, 5: I totally agree)

- if the slides were extensive enough,
- if they were clear and demonstrative,
- if the animations were useful,
- if the slides were enough for learning the topics and
- the overall grade for the slides (1:poor, 5:excellent).

A summary of the results can be seen in Figure 13. A clear majority of the students found the slides clear and demonstrative; 57.5% gave at least 4 points. The students were also happy with the slides overall. About the extensiveness of the slides and their sufficiency for learning the topics there were different opinions. Many thought that the slides were not extensive enough and that they did not provide sufficient information for fully understand the topics. This matter is, however, not quite that trivial. The primal purpose of the lecture slides is to help the lecturer in visualising the concepts during the lectures. For this purpose the slides should contain only keywords and important tables and graphs. When used as self-study material, the slides could be more extensive. However, the more text the slides contain, the more they become a substitute for a course book and the less they are suited for the lectures. This is certainly a question of prioritisation and balancing and planning of the course material as a whole.
The free comments and improvement suggestions gave valuable information about the slides. The students thought that the visual layout was good. Many students desired, however, more explanatory text, especially about calibration of expert judgements.

Figure 13 The students' opinions about the lecture slides
One comment about the overall extensiveness of the slides was written straight to the point: "If the lecture slides are meant for self-studying without a lecturer, then they are a bit brief. Many things got clear during the lectures, when an explanatory graph was drawn on the black-board". One student pointed out that it would be good to learn the terminology also in Finnish.

5 Conclusions

The home assignment worked quite well as an evaluation tool of the students’ knowledge level regarding the topics of the course Mat-2.134 Decision-making and problem-solving. It can, however, be argued that the assignment measured more the ability and willingness of the students to seek and apply information than their knowledge level when starting to do the assignment.

On the other hand, the questionnaire turned out to be too long and time consuming to fill out, which may have undermined the quality of the answers. The section in which the students were asked to grade the different learning events, forming the most extensive part of the questionnaire, did not give much valuable information. The questions about the slides were more appropriate. However, most of the information was gained from the free answer questions. It can be concluded that a good questionnaire might be quite short and simple, with many possibilities to give free answers. One could e.g. ask the students to name three good and bad things about the course. Connecting the questionnaire answers with the corresponding home assignment results might have given further insight about the different learning methods. This would have, however, required permission of the students, because of the loss of their anonymity.

According to the home assignment and questionnaire results, the educational goals of the course were met. The students relied mainly on the lecture slides and training session answers in the course handouts and very few actually read the course book. The book might have been read more extensively, if the reading had been instructed in more detail. It was expected that different learning events would have been useful for learning different topics. The results did not, with some exceptions, support this hypothesis.
As the course was not a true web course, major conclusions about web courses cannot be drawn on the basis of this study. The results do still show some strengths and weaknesses of e-learning. The web serves well as a distribution channel of basic information and written printable material. The other strengths lie in utilisation of the interactive, dynamic and multimedia characteristics of the web. It was assumed that the easier topics would be more suitable for e-learning than the harder ones. The results confirmed that the students preferred to learn difficult or demanding topics in traditional ways.

E-learning is surely an eligible option for some students, but will not supersede traditional learning methods. The most fundamental shortcoming in e-learning is the lack of face to face interaction and communication between students and teachers as well as between students among themselves. Web learning does also require high motivation and self-discipline.

The new lecture slides were found to be good although a little more explanatory text was desired. Further development, however, depends on whether self-studying or lecture visualisation is considered the main purpose of the slides. The section on calibration of experts needs to be improved and an English-Finnish dictionary of the key words would be of great use.
6 References


7 Appendix

Mat-2.134 Päätöksenteko ja ongelmanratkaisu syksy 2002 (Salo, Porthin)

B-osan kotitehtävä


Suoritusarvo yhteensä 10 pistettä

HUOM! Mikäli tarkistuksessa löytyy samanlaisia töitä (ts. selkeästi toisistaan kopioituja), niin kaikista tällaisista tehtävistä annetaan 0 pistettä. Muista vastata kyselyyn (ks. tehtävä 5)!

Tehtävät:

1. Selitä lyhyesti (n. 20 sanaa) seuraavat käsitteet: (1p)
   - Subjektiivinen todennäköisyystulkinta
   - Histogrammimenetelmä todennäköisyysestimoinnissa
   - Edustavuusheuristiikka (Representativeness)
   - Konjugaattijakauma
   - Toisen asteen stokastinen dominanssi
   - Value at risk –mitta

2. Toimit kioskin vetäjänä ja joudut päättämään, kuinka monta Helsingin Sanomien sunnuntainumeroa tilaat ensi sunnuntaiksi myyntiin. Lehtien ostohinta on 1,80 €/kpl ja myyntihinta 3,00 €/kpl. Ylijäämeet ovat arvottomia. Ensi sunnuntain kysynnälle olet estimoinut seuraavan subjektiivisen todennäköisyyysjakauman:

   \[
   \begin{array}{cccccccccccc}
   \theta & 16 & 17 & 18 & 19 & 20 & 21 & 22 & 23 & 24 \\
   P(\theta) & 0.05 & 0.10 & 0.12 & 0.16 & 0.10 & 0.20 & 0.10 & 0.12 & 0.05 \\
   \end{array}
   \]

   Kuinka monta lehteä tilaat, jos toimit seuraavien päätöskriteerien mukaan: (a) maximin, (b) maximax, (c) minimax regret, (d) moodikriteeri, (e) arvon odotusarvo (expected value)? Perustele vastaukset. Voit halutessasi käyttää esim. Exceliä. (2p)

Arviosi mukaan käytetyt tietokoneet ovat joko hyviä tai huonoja, joten päädyt tarkastelemaan vain kahta ääritapausta. Hyvän käytetyn tietokoneen korjauskustannukset ja päivitykset ovat kolmen vuoden ajalta 170 €. Huono käytetty tietokone sen sijaan aiheuttaa samalla ajan jaksolla 570 € edestä kustannuksia. Arvioit, että serkkusi myymä tietokone on hyvä todennäköisyydellä 0.3.

Ennen ostopäätöstä voit viedä käytetyn koneen huoltoliikkeeseen arvioitavaksi. Liike veloittaa arvioinnista 60 €, ja koska arvio voidaan tehdä saman tien ei ole riskiä, että serkkusi myy tietokoneensa ennen kuin saat arvioinnin tuloksen. Huoltoliikkeen antama arvio on joko tyydyttävä tai epätyydyttävä. Taulukossa 1 on esitetty arvion ehdolliset todennäköisyydet.

**Taulukko 1. Huoltoliikkeen tekemän arvion ehdolliset todennäköisyydet**

<table>
<thead>
<tr>
<th>Huoltoliikkeen arvio</th>
<th>Huono</th>
<th>Hyvä</th>
</tr>
</thead>
<tbody>
<tr>
<td>P(Tyydyttävä</td>
<td>* )</td>
<td>20%</td>
</tr>
<tr>
<td>P(Epätyydyttävä</td>
<td>* )</td>
<td>80%</td>
</tr>
<tr>
<td>Yhteensä</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Vaihtoehtoisesti voit antaa tietokoneen katsottavaksi asiaan perehtyneelle kurssikaverillesi, joka palaa viikon päästä Helsinkiiin. Hän ei pyydä palveluksesta palkkiota, mutta on olemassa 0.25 todennäköisyys, että serkkusi myy koneen toisaalle ennen kuin kurssikaverisi saapuu. Jos näin käy, joudut ostamaan uuden tietokoneen. Kurssikaverisi arvio ei kuitenkaan ole täysin luotettava, vaan olet päätynyt seuraaviin arvioihin sen luotettavuuden suhteen.

**Taulukko 2. Kurssikaverin tekemän arvion ehdolliset todennäköisyydet**

<table>
<thead>
<tr>
<th>Kurssikaverin antama arvio</th>
<th>Huono</th>
<th>Hyvä</th>
</tr>
</thead>
<tbody>
<tr>
<td>P(Tyydyttävä</td>
<td>* )</td>
<td>30%</td>
</tr>
<tr>
<td>P(Epätyydyttävä</td>
<td>* )</td>
<td>70%</td>
</tr>
<tr>
<td>Yhteensä</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Voit järjestää vain toisen arvioinneista. Miten menettelet, kun olet riskineutraali ja otat huomioon vain yllä mainitut asiat?

a) Muodosta päätöspuu ja ratkaise se.
b) Paljonko olisit valmis maksamaan siitä, että tietäisit serkkusi tarjoaman tietokoneen kunnon varmuudella, kun myös edellä mainitut arviointimahdollisuudet ovat käytössäsi.

c) Kuinka paljon kaverisi ehdolliset todennäköisyyet $P(\text{Epälyhytävä} | \text{Huono})$ ja $P(\text{Työhytävä} | \text{Hyvä})$ pitäisi muuttua (molempia muutetaan yhtä monta prosenttiyksikköä), jotta päätöksesi muuttuisi?

Rakenna päätöspuu ja tee herkkyyssanalyysi sopivalla ohjelmistolla, esim. Excel tai Precision Tree (ilmainen demoversio ladattavissa osoitteesta www.palisade.com). (4p)

4. Vastaat elintarvike-tuotantoon liittyvästä tuotantoprosessista, jossa joudutaan tukeutumaan aistinvaraiseen laadunvalvontaan. Tuotteiden laadun voi myös todeta valmiista tuotteista tehdyn kalliin, aikaavievän laboratorioanalyysin avulla, johon ei kuitenkaan yleensä ryhdytä. Tuotantoprosessiin viety erä hylätään, mikäli laatuindeksi jää yli 5 %:n todennäköisyydessä alle kynnystäesityksen kolmennielen. Esitä kymmenen kuvitteellista aistinvaraisten arviointien tn-jakaumaa kuvaavaa normaalijakauman tunnuslukuparia $(\mu, \sigma^2)$ ja kyseisten erien tarkat laboratoriottulokset. Kuvaa näiden avulla, miten toteuttaisit arvioijan antaman todennäköisyysjakauman kalibroinnin. (3p)