Conceptual Apprenticeship – Heuristic Simplification in Training Planning Students in Negotiation and Argumentation

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Abstract. Educational experiments 2003-2009 at the Swedish School of Planning, Blekinge Institute of Technology, have tested software and other tools in training students to acquire professional skills in negotiation and argumentation**.**

Results indicate that conceptual models, simplified, yet reflecting professional practice, facilitate learning. They do so by organising student efforts to acquire complex skills, providing immediate feedback and help to interpret teachers' hints and corrections. Simple models stimulate student elaboration. Complex models may need simplification and modification of target skills. In both cases improvement of learning outcomes can be observed.

Software helps in externalising professional methods, visualising outcomes, and diagnosing student errors. Software also presents operating difficulties and may lead to cognitive overload for some students. Contrary to common opinion in the field, results indicate that one should assume no clear relation between features of different software and learning outcomes. Educational contexts are unavoidably different, which makes comparisons difficult.

Modifying conceptual models and target skills, improving learning outcomes, should be seen rather as examples of *heuristic simplification* and *conceptual clarification*, supporting *conceptual apprenticeship*. This can be developed and reliably tested in a specific educational context.

Keywords:

Conceptual apprenticeship, heuristic simplification, negotiation, argumentation

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The Basis of Professional Skills – Apprenticeship or Research?

How do planners, engineers and architects acquire their professional skills? A traditional answer is: by apprenticeship, learning from masters. Tasks are presented to beginners, which represent typical difficulties of the profession, but in an elementary form.

Apprenticeship is practiced in many fields. A skilled craftsman; a carpenter, a welder, learns rules of thumb, imitates a master, and practices to achieve satisfactory results. Apprenticeship is also common in educated professions, among engineers, architects, medical doctors. The architectural student starts by designing a small weekend hut and goes on to more complex design tasks. The engineer calculates the appropriate properties of technical components and goes on to develop more complex constructions. The doctor learns how to diagnose common illnesses, and goes on to analyse more complex syndroms. They all need to apply available scientific knowledge as a basis for action. They are dependent also on a professional context: the guidance of more experienced colleagues, who know what scientific knowledge to apply, who can communicate and reflect upon this in a professional discourse, the acquisition of which is part of apprenticeship.

There is a problem, however, with apprenticeship. Professional knowledge is not reliable. Buildings rot, bridges collapse, money is wasted on huge and useless projects, patients die or become worse after medical treatment. (Dawes & Hastie, 2001, Flyvbjerg et al, 2003, 1998, Gigerenzer, 1999, Hall, 1982, Parkin, 2000, Rolf, 2008). Professional decisions are inconsistent, and experts often show unfounded confidence in their judgments (Plous, 1993).

Professions reserve the right to decide the standards of good practice. This can lead to young professionals sometimes learning only how to repeat the mistakes of older colleagues. There are also legitimate causes of the unreliability of professional judgment. Professionals deal with complex, non-deterministic socio-technical systems, where the feedback of actions taken is delayed. This makes it difficult to learn from experience (Rolf, 2008). Social problems in modern housing estates, for example, often take long time to emerge and are difficult to relate to the design of buildings and urban structure (Öresjö, 2004).

Another indication of the lack of reliable basis for professional judgment is rivalry between different pedagogic paradigms. In the field of architectural education, there are competing views of how architects should be trained. Diaz Moore (2001) identifies four main pedagogies of architectural education. It is difficult to see what kind of evidence would show that one pedagogy is better than the other.

This uncertainty has led to demands for a broader and stronger scientific basis for professional judgment. Britton Harris was a pioneer, who in the 1960s developed computer models for use in spatial planning. In his view, goal conflicts, great costs and often irreversible consequences mean that planning decisions should not be left to the judgment of individual professionals, however qualified (Harris, 1997). Formal models, preferably computer models, are needed to verify the consequences of recommended actions. Healey (1997) objects that formal models reflect fixed problem-framings and hinder continuous, mutual learning. They also tend to favour certain types of goals and consequences, which are easier to model in quantitative terms than others.

Recently, the demand for policy based on evidence has revived the debate on what is relevant knowledge for planning (Davoudi, 2006). According to her argument, an *instrumental* interpretation of “evidence” assumes a too simplistic, linear relationship between research and policy. This interpretation predictably calls for the development of broad databases, expert systems, and computer models to underpin policy decisions.

Davoudi questions the usefulness of this interpretation of “evidence”. There are indications that decision-makers do not want more knowledge about the issues. It makes decision-making more complicated. A legitimate reason for this may be that more information could make it more difficult to discover patterns and efficiently frame the problem, (Schön, 1983, Simon, 1997, Rolf, 2008).

Davoudi lists additional arguments against the instrumental use of knowledge. Experts are not always impartial but have self-serving professional agendas. Ideology and vested interests tend to demand knowledge that supports past decisions and may suppress opposing evidence. Instead she advocates an *enlightenment model*. The purpose of scientific research is rather to “illuminate the landscape within which policy decisions have to be made”. (Davoudi, 2006:16)

Heuristics – Simple Tools for a Complex World

So what should young professionals do? They cannot always trust their masters, and there is not sufficient, or sometimes too much scientific, conflicting knowledge, to guide them.

In view of this dilemma, Rolf (2008) identifies a group of *intermediate* methods for decision-making, between what are called “strong” and “weak” methods. “Strong” methods are used by professionals with expert domain knowledge, who quickly can reduce complexity by identifying relevant features of a problem – apprenticeship, in other words. The problem with these methods is the need to trust professional authority, with risks pointed out above, and difficulties in teaching these methods to beginners. “Weak” methods are general, based on scientific knowledge. They are valid, open to all, but also difficult for inexperienced professionals to apply to specific cases.

Heuristics is a term to denote *intermediate methods*, relying partly but not completely on domain knowledge. Heuristics elaborates on *representations* in order to support the process of inquiry, to identify patterns, and to connect problem formulation to a final decision (Simon, 1997) "Thus, heuristic methods are directed at managing processes." (Rolf, 2008:6, after Polya,1957).

The student of architecture is instructed, for example, to make "design experiments", working in the "virtual world" of developing outlines of three-dimensional designs, formerly on onion-skin paper, nowadays on the computer screen, evaluating the result, learning from it, modifying it in an iterative process that develops simultaneously the understanding of the problem and of the possibilities to solve it (Schön, 1983). See also Cross (2006).

Heuristics thus focuses on ways to *conceptualize* and *represent* problems.

Experiments in planning education

Training skills in negotiation and argumentation

At the Swedish School of Planning, Blekinge Institute of Technology (BTH), with programmes of Spatial planning and Urban Design at Bachelor and Master levels, a professional culture seems to be adopted quickly by students. Early enough they learn what seems to be the "code": synthesizing multiple requirements into an attractive design for improving urban environment and public space.

As in many schools of architecture and urban design, the emphasis is on innovative spatial arrangements that potentially solve several problems, functional and technical goal conflicts, while also satisfying esthetic requirements. Arguments when presenting planning proposals are mainly used to support the selected design. Self-critical evaluation is rare. Students are also reluctant to criticize fellow students' proposals.

The professional culture as perceived and adopted by students seems to be one of *consensus*, *collaboration* and *creation* of spatial arrangements that would satisfy multiple interests.

But planning is also *conflict*, *negotiation* between different interests and *analysis* of arguments for and against planning proposals (Forester, 1989, 1999, Healey, 1993, Törnqvist, 2006). Planners need the ability to construct and evaluate *hierarchies* of argument. Some interests are more important than others, because of more valid arguments. Analyzing chains of arguments is essential for *conceptual clarification,* reducing both *conceptual* and *epistemic* uncertainty, (Rolf, 2006, 2007a). "What kind of problem is this, and what do I need to know in order to solve it?"

It is symptomatic that according to Diaz Moore (2001), only one of his four pedagogies for architectural training lists *competitiveness* and *critical thinking* as characteristic of student roles. Two emphasize *collaboration* and one *individual dependence on a master*.

Consequently, teachers at the Swedish School of Planning have identified a need to strengthen the skills of *negotiation* and *argumentation* among planning students.

Cognitive Apprenticeship and Software

Negotiation and argumentation are skills that need both theoretical knowledge and practice. Fisher & Ury (1981) argue the merits of *principled negotiation*, arguing over interests instead of positions. Successful negotiation should aim to invent options for mutual gain, not one-sided "victories" of one party over the other. This requires insight, conviction and experience. Likewise, evaluating arguments and successfully using them needs both ability of logical reasoning and debating experience.

Collins et al (1989) have suggested ways of applying apprenticeship methods to the training of complex skills of this nature. In describing methods of *cognitive apprenticeship*, they emphasize the need to teach the *processes* experts use, not only having expert-teachers evaluate and correct the *outcomes* of apprentices' efforts. To do this teachers need to develop and transmit *conceptual models*, which help students to make observations of the expert way of solving a problem, models which help them to organize their attempts to execute the desired skill, and which provide an interpretative structure for making sense of coaching: feedback, hints and corrections. (op.cit:456).

Collins et al in their early paper foresaw that the core techniques of *modelling* and *coaching* could be formalised in computer software, suggesting that it could make a style of learning, previously limited, cost effective and widely available (op.cit:491).

A number of software products now exist to support the teaching of elementary reasoning skills. Recently Scheuer et al (2010) have presented a review of these products and tried to evaluate the effects of various features, such as visualisation techniques and feedback mechanisms on learning outcomes. The evidence is inconclusive. Some empirical studies find effects, others do not.

Rolf (2007b) argues against such *intercontextual* comparisons between software products. Learning contexts are unavoidably different from each other. Many unknown factors influence the learning outcomes. It is nearly impossible to draw conclusions concerning the effects of certain software features. Instead, Rolf recommends *intracontextual* testing, exploring the effects of various tools and conceptual models in a specific educational context. This is the approach presented and evaluated here.

Research Questions

What is adequate simplification in conceptual models of professional practice concerning negotiation and argumentation in spatial planning?

In what ways can software facilitate learning professional skills of this nature?

Conceptual Models in Negotiation and Argumentation Exercises

In line with the recommendation of Collins et al (1989), conceptual models for training negotiation and argumentation among planning students have been developed at the Swedish School of Planning. The criteria have been that models should be so comprehensive that they realistically illustrate professional tasks, yet so simple that they are possible to operate for inexperienced students.

It is in this context that *heuristic simplification* and the use of *software* have been tested. As will be shown below, software may help to model real planning tasks and give immediate feedback of attempts to learn a complex skill. Heuristic simplification takes place in describing the assignment, defining the target skill, giving instructions, presenting tools and forms of representation and providing feedback and correction.

Conceptual model is used here to mean the description of a planning situation, in which professional skills are to be trained. It necessarily represents a simplification of a real planning situation. The number of actors and stakeholders is limited, the number of planning issues, subject to negotiation and argumentation, is limited.

The *assignment* is the task set for students within this conceptual model: for example, to negotiate an outcome, which the negotiating parties can accept, to organise and evaluate all presented arguments in a planning case, or to select the strongest arguments and recommend a decision.

Target skills are the skills the assignment intends to develop with the help of instructions and tools. The target skill can be to defeat an opponent in negotiation, maximising gain at his expense, or to find negotiation outcomes for maximum combined gain. The skill can be to organise and evaluate all presented arguments in a logically consistent way, or to identify only the strongest arguments and present them in support of a decision.

Instructions are written and oral information, describing the conceptual model, the assignment, as well as guidelines, coaching, feedback, advice and corrections in teachers’ interaction with students.

Tools are software and paper forms, providing forms of representation, both of the conceptual model, and for the presentation of student results.

The Negotiation Exercises

The conceptual model in these exercises was a planning situation, where a private property developer would negotiate with municipal planners on the terms of developing a central piece of land: a former hospital with a surrounding park. Preliminary discussions had resulted in agreement that the parties would meet to negotiate on four parameters:

land use, with the alternatives housing, offices, park, or a mix.

plot ratio

land rent, to be paid by the developer to the municipality.

start date

Students were divided into teams, half of the teams representing planners and the others the developer. They received written instructions, including the weights for each parameter and utilities for each value. For example, the planners would have a weight of 60 % on land use, and a utility of "100" for a mix of housing and offices. The developer would have a weight of 80 % for this parameter and a utility of "100" for offices only. The teams were instructed to find out how they could make gains of utility, while making limited concessions.

After negotiation the teams reported the agreed values for each parameter. This data was fed into Athena Negotiator software (www.athenasoft.org), which is based on a mathematical model for multi-criteria analysis, calculating the maximum combined gain possible with given weights and utilities for each party. On the computer screen the students could immediately see how close to this optimum outcome they had come. In the first round, several teams failed to reach their maximum gain, realising that they had given unnecessary concessions to the other party. In the second round, teams switched roles, and in that way learned of the priorities of the other party. In a third round, students were allowed to set their own weights, this after a suggestion from students one year.

Results of negotiation exercises

Students have showed consistent improvement of negotiation outcomes in these exercises. After three rounds they have approached the maximum combined gain, moving their results toward the top right corner of the diagram showing possible outcomes. See Fig 1. Earlier outcomes closer to origo showed suboptimal gains for each party; results close to either the y- or the x-axis revealing gains for one party at the expense of the other.

Students told in evaluation that they quickly learned how to exploit the different priorities of each team, but complained that negotiation turned out to be too much calculation. They wanted to make better use of their persuasive and creative skills! The teacher explained that in real negotiations there would be plenty of opportunities for this, both before and after the simplified and tightly structured negotiation practiced in this exercise. There would be discussion about which parameters should be subject to negotiation. Planners would argue with councillors before negotiation about possible land-use and plot ratios, presenting creative designs that combined high plot ratio and land rent with attractive housing qualities, setting the utilities accordingly. After agreement on land rent the developer, on the other hand, could suggest payment in kind, like financing extra landscaping.

Student evaluations of these exercises consistently have been very positive. In contacts with students at other Swedish schools of architecture, BTH planning students have suggested that this kind of negotiation exercise should be included in the curriculum of other schools.

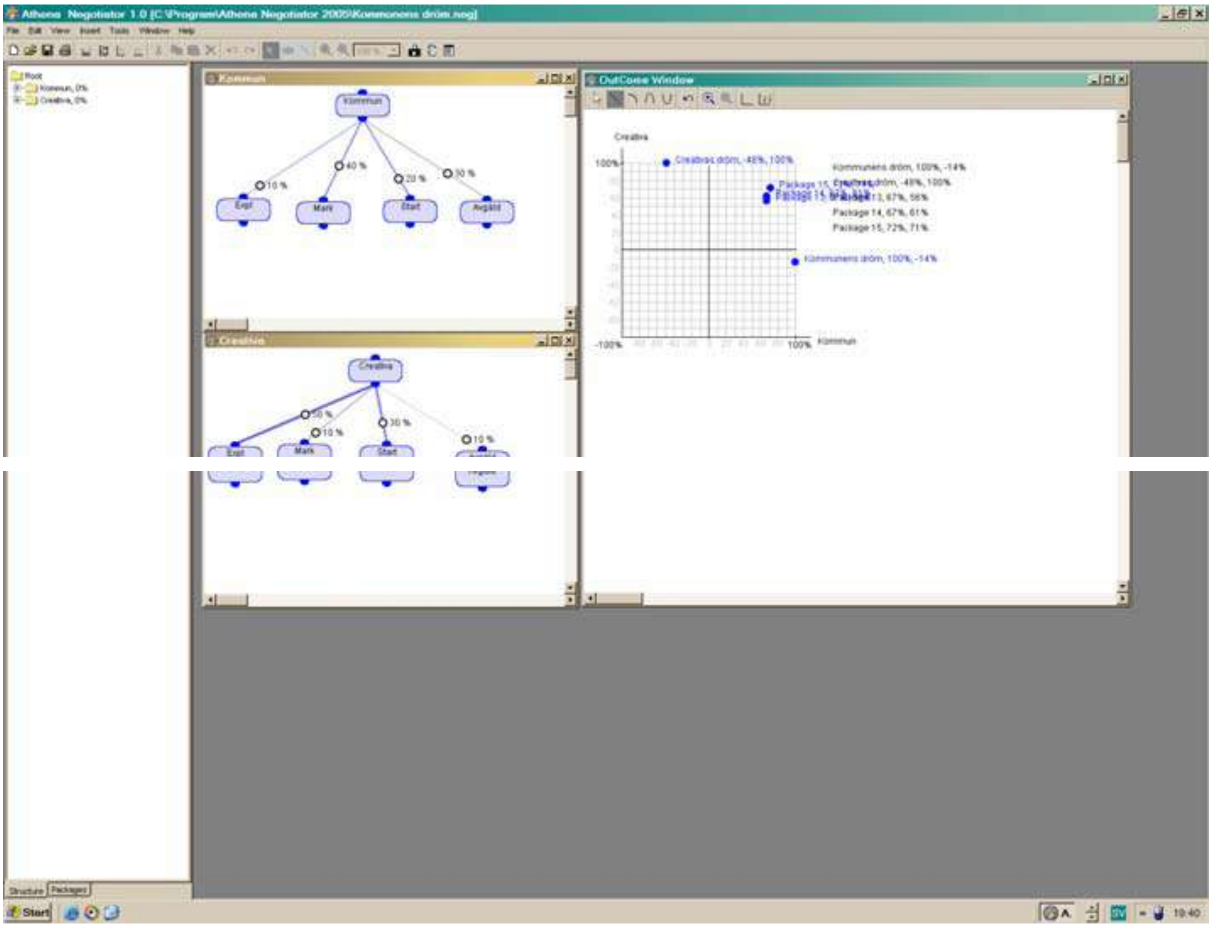

Fig 1. Athena Negotiator showing parameter weights of each party (left) and negotiation outcomes after three rounds (right). The outcomes of all teams are now concentrated in the top right corner, close to the position of maximum combined gains, as calculated from the priorities of the negotiating parties: developers and planners.

The Argumentation Exercises

The conceptual model in this exercise was based on a complex planning case that had been appealed at all administrative and judicial levels and finally decided by the national government. The documentation of the case was provided by the National Board of Housing, Building and Planning, in a report on how the planning system handled conflicts concerning workplaces (Boverket, 1995).

Municipal planners in this case had proposed a plan allowing for densification of an old housing estate, originally built at the end of the 19^{th} century for workers at the adjacent steel plant, which was still in operation. The buildings had been modernized, but the housing estate was still considered uniquely preserved and a valuable part of the industrial heritage.

The rationale for densification was the need to finance renewed technical infrastructure and to provide a broader population base for social and commercial services. There was pollution in the form of dust and noise from the steel plant, occasionally exceeding national norms. The current plan had provided for these health hazards by restricting new development to areas farthest away from the plant. A court order had also required the plant to eliminate dust emissions by encapsulating certain industrial processes within three years. The National Board of Antiquities considered that new development according to the plan was possible without impairing the cultural heritage qualities of the estate.

In preparation the teachers extracted twelve arguments presented by stakeholders and authorities during the long planning process, as documented in the report (Boverket, 1995). The conceptual model of the exercise proposed that the student would play the role of an expert civil servant at national government level, weigh the evidence, and recommend a decision to the Minister of the Environment.

The assignment for the students then was to structure and evaluate the list of arguments with the help of Athena Standard software, specially developed for argumentation analysis (www.athenasoft.org, Scheuer et al 2010). The software made it possible to visualise and describe arguments in a diagram, to set values on their acceptability and relevance and to connect them with other arguments in pro- or con-relations. See Fig 2. The software also made it possible to filter out the weakest arguments (the strength based on the product of values of acceptability and relevance). In that way the students could verify whether their evaluations of single arguments supported their main thesis – a decision for or against approving the plan for densification.

Instructions included a list of guidelines for applying values of *acceptability* and *relevance* to arguments. This list was set up as a result of discussions with professional planners with experience of planning at the municipal, as well as regional and national levels. It was agreed that *relevance* primarily should be related to legal rights and obligations of authorities and stakeholders to take part in the planning process. The arguments of neighbouring landowners, the County Administrative Board, expert government agencies, like the Swedish Environmental Protection Agency, consequently would have high relevance. *Acceptability* on the other hand would depend on the factual basis for their arguments. Arguments referring to measurements of noise levels as compared to national norms would have high acceptability, for example, whereas mere opinion on environmental disturbance or quality would have less acceptability.

After some introductory experimentation, the conceptual model including twelve presented arguments, and the guidelines for evaluating acceptability and relevance have been constant for the last four years (2006-09). Different tools have been tested: the Athena Standard software, Mind Manager software and simplified paper forms. The effects of these tests can be studied in Figure 2 and Table 1.

Year No of students	2006 49	2007 47	2008 54	2009 27
Tools	Students first make an individual evaluation of arguments on a paper form. Then groups of 3-4 students make the same evaluation with Athena Std.	Students work in parallel groups with Athena Std, Mind Manager and a paper form.	Students work in parallel groups with Athena Std, and two paper forms, one simplified.	All students work with the simplified paper form.
Errors in student presentations[2]	B1: 52% A: 31%	A: 57% B1: 56% MM: 60%	A: 33% B1: 33% B2:17%	B2: 19 %
Students who recommended the same decision as the government actually made in the case.	B1: 40 % A: 69 %	A: 80 % B1: 100 % MM: 100 %	A: 67 % B1: 67 % B2: 86 %	B2: 96 %

Table 1. Argumentation exercises 2006-09

A = Groups using Athena Standard software.

B1 = Groups using a paper form with list of arguments and instruction to value each arguments according to acceptability and relevance and recommending a decision.

B2 = Groups using a simplified paper form with list of arguments and instruction to indicate the 3-4 strongest and weakest arguments and explaining their recommended decision.

MM = Groups using the general purpose visualization software Mind Manager and recommending a decision.

[2] Errors are of two kinds 1. Pro-con errors. Athena Standard software requires that the pro-con relation refers to nearest argument above in the tree, not to the main thesis, which many students assumed. When filtering out the weakest arguments, this may lead to the result that the student's strongest arguments do not support the main thesis and the recommended decision. If the student doesn't realise this, it is considered a thinking error. 2. Logical errors. For example: Two arguments are connected, which seem to have no logical or factual relation. Or one argument is presented as support for two opposing arguments. A strong counter-argument obviously weakens the first presented argument. If acceptability and relevance values of the first argument then are not adjusted, it is a logical error. Logical errors can occur when using other tools than Athena Standard. The figures indicate the percentage of students with one or more of these errors.

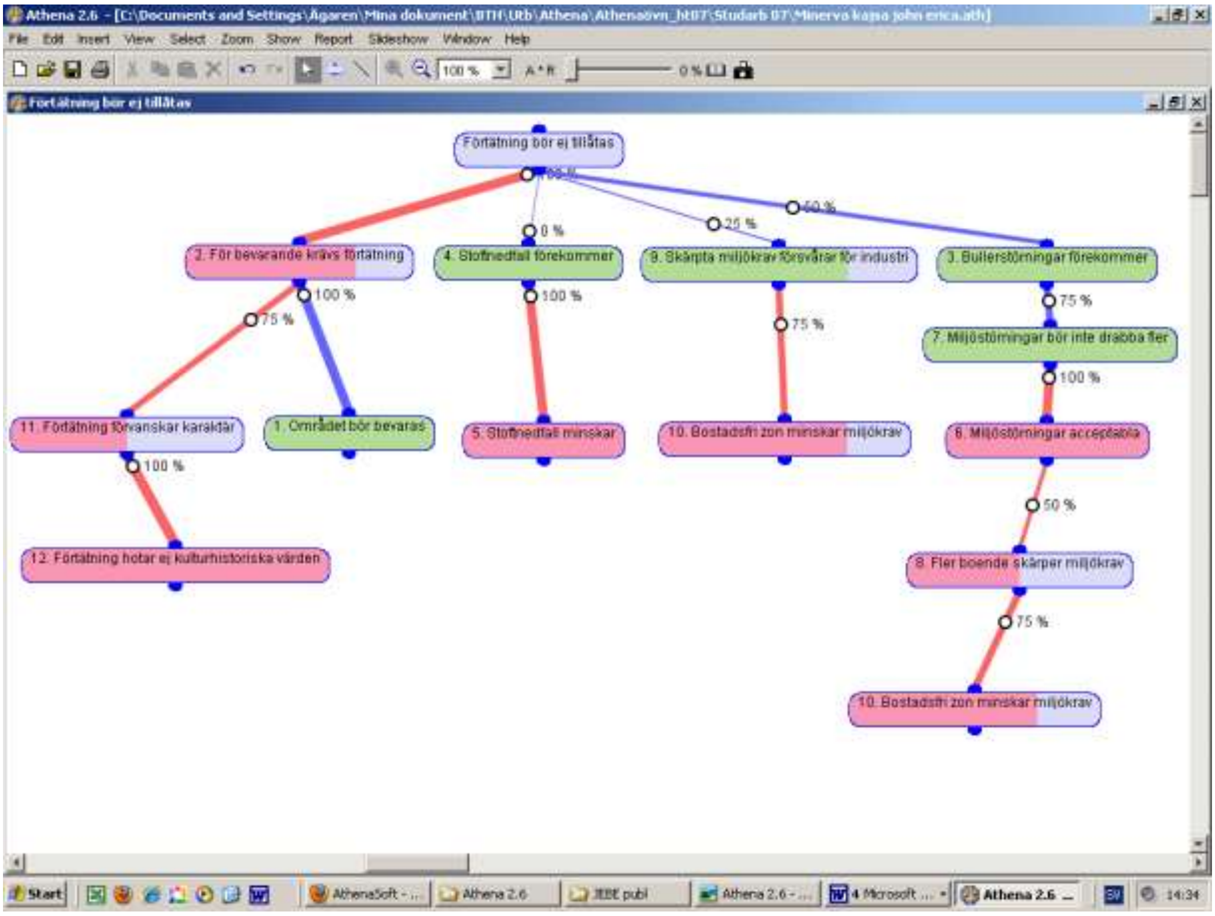

Fig 2. Example of argument tree in Athena Standard. Fully green-coloured nodes signify highly acceptable pro-arguments. Red nodes signify counterarguments. The width of connecting lines indicates the relevance of the argument to arguments immediately above. Filtering out the weakest arguments shows if the main thesis on top receives support or not. In this tree,strong counterarguments lead to defeat of thesis that densification should not be allowed.

Results of Argumentation Exercises

The students have had difficulties using Athena Standard software to structure and evaluate arguments in the planning case. Some students were able to build clear argument trees, identifying important chains of arguments, gaining insight in the planning process, detecting weaknesses in arguments and the need of additional evidence. Many students seemed confused, however, by the assignment to build argument trees, and revealed thinking errors. Some errors may have been due to insufficient understanding of the requirements of the software, primarily that pro- and con-relations should be related to the argument immediately above in the argument chain, not to the main thesis. See note in Table 1.

Other errors seemed more fundamental, like connecting arguments that seemed to have no logical or factual relationship, or marshalling one argument in support of two opposing arguments. Several students also failed to understand that strong counter-arguments weakened the acceptability of other related arguments, which led to inconsistency and insufficiently founded recommendations for a decision on the case.

The software diagrams produced by the students in earlier exercises made it easy for the teacher to discover these errors and indicate corrections. A small majority of the students succeeded over the years in finding a consistent recommendation, which also conformed to the actual decision of the government in the case. See Table 1.

To a great extent, however, student evaluations of using Athena Standard in this exercise have been negative.

The software difficulties led in the following years to the introduction of paper forms, where students were asked to make the same evaluation of arguments, but without having to build visual argument trees with the help of software. The results were inconclusive. Significant thinking errors were found in all groups, whether using software or paper forms in the year of 2007. See Table 1.

In 2008 a simplified paper form was introduced. Students in one group were only asked to indicate the strongest arguments, without rating their acceptability or relevance, and to recommend a decision. The low rate of thinking errors observed in this group led to the experiment in the final year 2009, that all students would use only this simplified form, and in addition explain their way of thinking when evaluating the arguments and recommending a decision. This experiment was partly intended to serve as a base-line indication. How would students reason in a planning case, with a minimum of instruction and tools to help them to structure and evaluate the arguments?

The result was unexpected. The rate of thinking errors, when using this simplified form was almost the lowest among student presentations during the whole testing period (Table 1, year of 2009). When describing their thinking process, a strong majority of students demonstrated consistency in evaluating arguments, relating them to a clear hierarchy of values, e.g. that concerns of health and protection of the environment were more important than economic interests. Professional expertise was also considered more credible than expression of partial interests. Students identified at least two levels of arguments, realizing that a strong counter-argument weakened the strength of a previously presented argument. For example, dust pollution at the housing estate, would in consequence with a court order be substantially reduced in three years, strengthening the argument for densification.

A majority of students also identified inconsistency in arguments of the Swedish Environmental Protection Agency on the case. The agency argued that existing levels of pollution were acceptable, but still disapproved of densification if more people would be subject to pollution. Students argued that if pollution was acceptable for some people, then it should be acceptable for all. And if not, not.

Discussion

Consistently satisfactory learning outcomes in the **negotiation exercises** verify the usefulness of a conceptual model, which although simple, reflects a complex professional context, and stimulates student elaboration. The simplification, of course, consists in including only four negotiation parameters and providing numerical weights and utilities for these parameters and their values. This makes the conceptual model an easily operated, predictable system, which in combination with immediate feedback, facilitates learning, according to several studies (Rolf, 2006). The fact that this feedback has been visual as well as numeric and verbal may also have contributed (Tufte, 1983).

The adequate simplicity of the conceptual model was confirmed by the fact that students quickly suggested elaborations, such as varying the weights of the parameters according to personal preferences. They also asked for opportunity to develop their persuasive and creativity skills further, for example, as teachers suggested, by introducing additional parameters in the model. This supports the recommendation by Collins et al (1989) that a conceptual model should provide an internalized guide for independent practice and further improvement (op.cit: 456).

The improvements observed also support common principles of negotiation, claiming that increased understanding of the interests and priorities of one's opponent, as well as of your own, facilitates mutually satisfactory outcomes (Fisher & Ury, 1981).

The learning outcomes of the **argumentation exercises** have been more varied and give rise to questions concerning the stability of the educational context, the adequacy of the conceptual model, definitions of targets skills, forms of representation and effects of features of the software and other tools.

The educational context seems to have been stable during the latest test-period of four years. The conceptual model and the teachers have been the same. The motivation and the ability of the students may have varied, however, as well as the amount of teacher instruction and student interaction. The improvement of learning outcomes in 2006, when students first individually used a simple paper form, and then in groups used the Athena software to model chains of argument, may have been a result of several factors: practice by repeating the exercise, group interaction and intensified teacher instruction in using the software.

There has been stable recruitment of students over the years to the Master programme of Spatial planning; no difficulty to fill the quota, but no obviously sharpened competition, which could have increased the number of students with better scholastic merits and potentially better reasoning skills.

The latest exercise in 2009 gave an opportunity to test for possible variations of student ability. The results of the argumentation exercise were matched with evaluation from teachers in other courses of the varying ability and dedication of students in the class. Several students, who were considered poor performers by other teachers, nevertheless did well in the argumentation exercise. The few students demonstrating weak reasoning skills in this exercise also were poor performers, according to this evaluation. The conclusion is that the conceptual model as such apparently was sufficiently simplified and possible to operate for most students.

Another factor to have influenced the improved outcomes with the simple paper form in 2009 could be better understanding of the planning process by students. In earlier exercises teachers noted that difficulties to organise arguments in graphically clear argument trees could stem perhaps from insufficient knowledge of the Swedish planning process, where planning proposals are subjected to several reviews and appeals in a complex system. After only one year of study this could be understandable.

The results then would have indicated that the conceptual model; the planning situation presented, and the assignment, were insufficiently simplified. In 2009, however, coaching students in the assignment indicated to teachers that many students now seemed to have a better grasp of the planning process. An observed high level of student interaction in the studios this year could explain this. It could also be due to improved teaching in other courses during the first year. This, of course, would be difficult, although highly desirable to verify. The satisfying learning outcomes this last year confirmed, however, that under present conditions the conceptual model as such apparently was adequate.

The observation that some students using the graphic possibilities of Athena software developed a deeper understanding of the planning issues and the nature of the evidence seems to match the results of Suthers & Hundhausen (2003). They compared student groups using a *graph* representation with *matrix* and *text* representations of issues and arguments. They found that while matrix users represented and discussed a greater number of evidential relations, graph users may have been more focused in their consideration of the relevance and acceptability of the evidence. But this could be mere coincidence and one must agree with Rolf (2007b) that educational contexts are so different when testing software and other tools for training reasoning skills, that one should assume no clear relation between features of such tools, or forms of representation, and learning outcomes.

The suggestion by Scheuer et al (2010) that using software to model argumentation may lead to cognitive overload finds support in the evaluation of the argumentation exercises. The teachers considered the Athena software easy to use, practically self-instructive. The planning students could also be considered proficient in using GIS-, CAD- and other software, presented and trained at the school. Nevertheless, several students had difficulties as mentioned, using Athena for structuring and evaluating the listed arguments. The satisfying outcome of using a simplified paper form in the latest years seems to confirm the notion that the software was unnecessarily demanding and contributed to cognitive overload for some students.

One must realise, however, that this simplified paper form also represented a modification of both the target skill and the assignment. In the latest exercise students were not asked to organise and evaluate the complete provided list of arguments, but to indicate only the 3-4 strongest and the 3-4 weakest arguments and to use this evaluation as the basis for a decision.

There are reasons to believe that this simplification may have been the decisive factor. Studies of practical decision-making indicate that decisions are usually made on the basis of a few factors and arguments only (Davoudi, 2006, with references). Rolf (2007b) cites evidence that natural ability to identify and evaluate long chains of argument is indeed not common. Developing this ability normally requires long and specialised training, for example in the fields of philosophy, natural science and law.

For planning students the relevant target skill may be that they show an ability of consistently evaluating a limited number of arguments and clearly express their reasons for the selection and the evaluation. The latest educational experiments confirm that this is what students manage to do, when presented with a sufficiently simplified conceptual model.

Distinguishing between the *acceptability* and the *relevance* of an argument seems fundamental in argumentation analysis. Nevertheless, several students neglected in the earlier exercises to use instructions to evaluate arguments in these terms and to build argument trees with Athena software accordingly. Even when they did, many failed to draw the proper conclusions, for example, that a highly acceptable counterargument should weaken the acceptability of related arguments.

In line with this was the observation that hardly any students, when explaining their thinking in evaluating arguments on the simplified paper form the last year 2009, explicitly mentioned either *acceptability* or *relevance*. One could, however, identify an implicit evaluation of arguments in these terms. Most students, for example, declared that they gave stronger weight to arguments presented by expert government agencies, than to arguments from private interests, like an industrial company or neighbours. From their formulations it seemed that the reason for this was both an assumed higher degree of expertise (acceptability) and a higher degree of impartiality (influencing both acceptability and relevance). Whether this confidence by planning students in government authorities is well-founded is one thing. It could reflect an early developed professional bias. After all, government agencies could be future employers.

What is important is whether this way to evaluate arguments is logically consistent, which it is. Consequently, simplification in this respect, not distinguishing between acceptability and relevance, does not seem to weaken learning outcome in view of the target skill.

Conclusions

Student use of simplified conceptual models facilitates learning. The models should be so comprehensive that they realistically illustrate professional tasks, yet so simple that they are possible to operate for inexperienced students.

The advantage of using software to represent and operate conceptual models needs to be balanced against operating difficulties. Although software may support heuristic simplification, helping some students to achieve conceptual clarity and helping teachers to diagnose thinking errors, some students may still be unable to develop a deeper understanding of the planning issues because of difficulties to use the software. Features of different software seem unable to explain these difficulties.

Obviously simplification is inevitable when designing conceptual models for training complex professional skills. Results indicate, however, that *heuristic simplification* can be carried far and tested reliably within a specific educational context. Using software to visualize negotiation outcomes consistently has improved negotiation skills, when using a conceptual model for negotiation on planning issues, simplified, yet reflecting professional practice. The results confirm findings in other cognitive studies, that a conceptual model providing immediate and predictable feedback, facilitates learning.

The results of the argumentation exercises underline the importance of defining the target skill. In the negotiation exercises the target skill was to achieve maximum combined gain. Using software to illustrate this improved learning outcomes. In the argumentation exercises the target skill was modified after evaluation, also resulting in improved learning outcomes.

An interpretation of this result is that planning students must not perhaps achieve the ability of court lawyers to structure and evaluate complete chains of arguments. It could be sufficient that they identify the strongest and weakest arguments in a case, that they are able to discern at least two levels of arguments and counterarguments, to discover contradictions in arguments of stakeholders, and to make consistent evaluations of arguments, leading to a reasonable and transparent decision. This was what a majority of students managed to do, documenting in a final exercise a minimum of thinking errors.

Thus, the *negotiation exercises* have indicated that heuristic simplification may have been carried too far, spurring students to suggest elaborations of the *assignment*. In combination with immediate feedback, this has led repeatedly to improved learning outcomes.

The effects of modification of the *argumentation exercises*, in a complementary way, have demonstrated that the complexity initially may have been too great. Successive heuristic simplification of the *assignment*, *target skills* and *tools*, consequently also have led to improved learning outcomes.

Conceptual apprenticeship is a term suggested for the training of this type of professional skills.

There are indications that it may be more difficult to use software to structure and visualize arguments of others, than to use it to develop a thesis of one's own. Further studies should test this, instructing students to identify, on their own, arguments from planning documentation, and to structure and evaluate these arguments with the help of different tools.

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