# Inclusion of Pedigree-analysis (NUSAP) in undergraduate science education: An example

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Aalborg University applies a problem-based learning model. Each semester all students form groups. Group members formulate and agree upon a problem they want to address, within their course of study, and write a long report on their findings (length depends on the year of study, the number of group members etc.). Key principles for the choice problem is praxis-orientation, inter-disciplinarity, and contextualisation.[1] To facilitate inter-disciplinarity two supervisors – a disciplinary and a contextual – might be associated with student groups.

We are a team of seven undergraduate students of Chemistry, Environmental technology and Biotechnology study-programme at Aalborg University, and our contextual supervisor. In our second semester (February-May 2008) we were working on the problem "*What is the risk of methane migration into houses situated on the terminated landfill "Skrænten" in Hjørring, Denmark?"* Our work with the problem consisted of both a technical part and a contextual part. In the technical part we investigated the theoretical foundation of methane production in landfills and we measured the concentration of methane at different places at the landfill Skrænten in Hjørring. In the contextual part we did a NUSAP analysis on the risk assessment of the gas-producing landfill that had been carried out by the local authorities.[2]

In Denmark environmental risk assessment conventionally consists of three phases: *orientation*, *primary field examinations* and *supplementary field examinations*.[3] In risk assessment of terminated landfills, the orientation phase includes data-collection about contents and waste disposal, geology and the top cover of both landfill and the surrounding areas. The phase of primary field examinations includes mapping the extension of gas producing areas, and measurement of gas concentrations in and adjacent to the landfill. The phase of supplementary field examinations is only conducted if the measured gas concentrations are higher than a threshold value. These examinations may include expanded examination of the gas producing areas, examination of gas migration and soil permeability, measurement of gas concentrations inside buildings, and data-collection concerning engineering conditions on these developments, such as which materials were used in construction of the basement and floors, how the ground beneath houses have been prepared etc.

The local authorities responsible for the landfill "Skrænten" in Hjørring, Denmark conducted a thorough risk assessment from 1994 to 2002, in cooperation with different Danish engineering companies.[4] The assessment concluded that the landfill emitted methane, but that there was no risk for explosions in buildings situated on the landfill when ventilation was installed -- even when considerable concentrations of the explosive gas were present underneath the foundation of the buildings.

Our group acquired a copy of the risk assessment, that consisted of more than 30 documents, by contacting the local authorities. We selected five documents that contained information about gas concentration measurements (taken at different times before and after ventilation was installed, underneath buildings and in the surrounding areas), and carried out a NUSAP analysis on those.[2]

We shortly assessed the first four elements in the NUSAP analysis (Numerical, Unit, Strength, Assessment), and then focused on setting up a Pedigree-matrix, and applying it on the information in the selected parts of the risk assessment.

The Pedigree-matrix we set up, is shown in table 1. It is based on the matrix presented and explained in the nusap.net tutorial "NUSAP".[2] We have customized our matrix to our specific case. The main differences are the change of name in the first criteria from "Definitions and Standard" to "Problem", and the change of the definitions of grade 3 and 4 within this criteria. Also, we only saw the need of one grade of 0 in each criteria.

| Grade | Problem | Data-collection and analysis | Institutional culture | Review |
|---|---|---|---|---|
| *4* | Scientific experts and fieldworkers | Task-force | Characterized by dialogue | External |
| *3* | Scientific experts | Direct survey | Characterized by accommodation | Independent |
| *2* | Convenience | Indirect survey | Characterized by obedience | Regular |
| *1* | Symbolism | Educated guess | Characterized by evasion | Occasional |
| *0* | Unknown | Unknown | No contact / Unknown | None / Unknown |

***Table 1.*** The Pedigree-matrix that we applied to the five documents from the risk assessment of the landfill "Skrænten", Hjørring, Denmark.

To evaluate the quality, and thereby the reliability, of the information in the risk assessment documents, six of the seven students in the group acted as "experts", and assessed the five documents individually in comparison to the criteria in our Pedigree. We justified our role as "experts" by noting that we had been working with the subject matter in 8-10 weeks prior to the NUSAP analysis.

Based our six individual assessments an average was calculated for every document for each of the four Pedigree-criteria. The results are displayed in the kite-diagram shown in fig. 1 (the five documents are represented by different colours). The highest and lowest of our assessments for the specific document "Purple", are displayed in another kite-diagram, showed in fig. 2, giving a rough outline of the spread of our assessments.

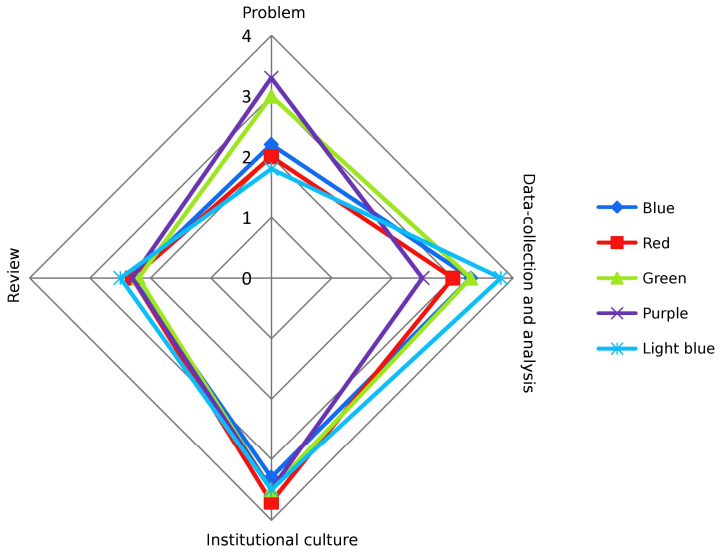


***Fig. 1.*** Kite-diagram displaying the average Pedigree-results of each of the five documents. The documents are named Blue, Red, Green, Purple and Light blue.

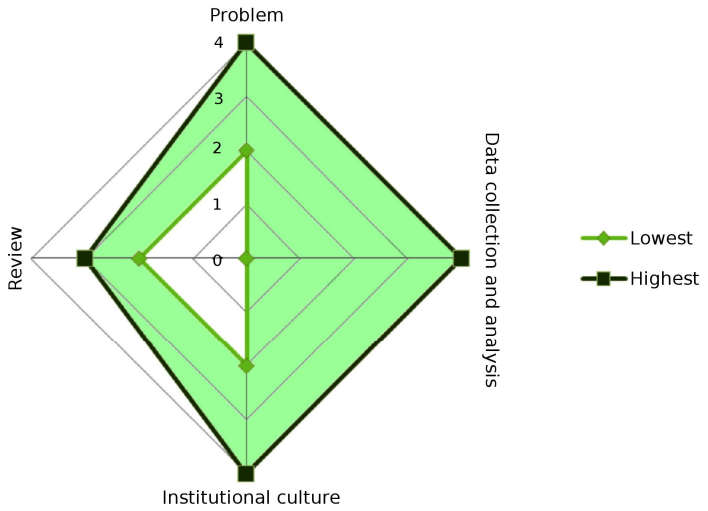


***Fig. 2.*** Kite-diagram displaying the lowest (Lowest, light green) and highest (Highest, dark green) of our "expert" assessments on the document *Purple* from Fig.1.

The average results of the five individual documents (fig. 1) show that the assessments of the criteria "institutional culture" and "review" are similar for the five documents, whereas the average values for "problem" and "data-collecting and analysis" differ considerably from document to document. "Institutional culture" is assessed very high, "review" around middle, "problem" and "data-collecting and analysis" from just below 2 to close to 4.

The average assessment of the criteria "problem" in the document "Purple" is close to excellent (grade 4) as the only one of the five documents in this criteria. This means that the local authorities initiating the risk assessment, scientific experts and people working in direct and daily contact with the landfill agreed on the problem addressed in the purple document. This high grade suggest dialogue, which here means involvement of stakeholders in the formulation of the problem.

Also in the criteria "data-collection and analysis", only one document has been graded close to excellent. We find the highest average in the document "Light blue". The grade 4 in this criterion, signifies that data-collection and analysis was carried out by a task-force – i.e. a diverse group of experts with extensive knowledge within the area – that produce information that is tailored to the problem at hand.

The high average assessment of institutional culture in all the documents reflects a transparent and non-authoritative environment characterized by dialogue. Our assessment of review, a little above middle, tells that no external or independent parties have reviewed the documents.

If we are going to make a specific conclusion on the quality of the local authorities' risk assessment of the terminated landfill, based on our results, it would be that the presentation of information in the risk assessment needed to do the Pedigree-analysis, could have been higher. The documents reflect, at best, a high amount of implicit or tacit knowledge. Furthermore, the presence dialogue the institutional culture is not consistently reflected in the assessment of other criteria. Stakeholders are rarely asked when problems are formulated or when results are reviewed.

It was not easy to apply the Pedigree / NUSAP tool to the risk assessment, due to the high degree of tacit knowledge in the analysed documents. The five documents originate from different sources, and none of them seem to be prepared for scrutiny with the NUSAP tool. Our results may be affected by the group's inadequate understanding of uncertainty assessment and the NUSAP tool: It was for example not easy to differentiate between the middle grades in the Pedigree-matrix.

It is interesting to notice the considerable variation in our individual assessments within each criterion, illustrated by the document "Purple" (see fig. 2). Can this be accounted for on the basis of our lack of experience in the exact sciences? Would the assessments of trained scientists and engineers have been any different? In a quantitative normal scientific risk assessment, more experience would produce more homogenous results. However, in post-normal science, a

quantitative analysis is not adequate, and subjective / non-objective assessments have to be considered, displaying a more heterogeneous outcome.

Our assessment of "institutional culture" does not depend on the specific documents, like the other three criteria. All documents have been formed in the same culture, which explains why the assessments of the five documents' "institutional culture" are similar. Our assessment of the criteria "review" does not directly relate to the specific documents, but are based on our knowledge of local authorities and the engineering companies involved. It was not evident from the documents how they specifically had been reviewed. That our assessments of "review" do not score as high as those of "institutional culture", may also show that we are not yet fully integrated the engineering community, and hence do not perceive tacit evaluation mechanisms.

In our line of study (*Chemistry, Environmental technology and Biotechnology*) we consider the theory of post-normal science to be highly relevant, and NUSAP as an applicable tool for vital understanding of scientific research in this area. It is important to scrutinize the technical aspects that form the basis of quantitative scientific research, and ask qualitative questions such as "why was this done?" and "where does the result come from?"

**References**


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