Working Paper

Education in environmental planning effects of group discussion, expert information, and case study participation on judgement accuracy

Author(s):
Hansmann, Ralph; Scholz, Roland W.; Crott, Helmut W.; Mieg, Harald A.

Publication Date:
2001

Permanent Link:
https://doi.org/10.3929/ethz-a-004336054

Rights / License:
In Copyright - Non-Commercial Use Permitted
Education in Environmental Planning: Effects of Group Discussion, Expert Information, and Case Study Participation on Judgment Accuracy

Ralph Hansmann, Roland W. Scholz, Helmut W. Crott, and Harald A. Mieg

November 2001
Education in Environmental Planning: Effects of Group Discussion, Expert Information, and Case Study Participation on Judgment Accuracy
Ralph Hansmann, Roland W. Scholz, Helmut W. Crott, Harald A. Mieg

Abstract
Which type of instruction can improve the skills in environmental planning? This article analyzes the learning effects of three different forms of instruction: (1) Participation in a case study, (2) group discussions, and (3) group discussions including the disclosure of expert judgments. The effects of these formats on the accuracy of students’ judgments on impacts of selected environmental variables are analyzed. 80 students who were involved in a case study on ecological regional planning participated in the study. A longitudinal analysis that compared the accuracy of students’ judgments at the beginning vs. at the end of the case study showed that the quality of students’ judgments increased significantly. A field experiment was included in the study to analyze the influence of disclosed expert judgments on the formation of students’ judgments during group discussions. In this experiment, expert judgments were disclosed at the beginning of the group discussions in half of the discussion groups, but not in the other half of the groups. Students’ individual judgments approached generally the expert judgments in the course of the group discussions. This effect was stronger in the groups where the expert estimates were disclosed.

Contents
Abstract........................................................................................................................................................................................................................................1
Contents......................................................................................................................................................................................................................................1
Introduction ...........................................................................................................................................................................................................................2
Case Study Participation....................................................................................................................................................................................2
Group Discussion ......................................................................................................................................................................................................3
Group Discussion Including Information on Expert Judgments............................................................................5
Method........................................................................................................................................................................................................................................7
Task and Experimental Context ....................................................................................................................................................................7
Procedure and Experimental Design................................................................................................................................................... 8
Results........................................................................................................................................................................................................................................12
Accuracy of Students’ Judgments at the Beginning and at the End of Case Study Participation (Longitudinal Analysis).................................................................12
Influence of the Disclosure of Expert Judgments on Opinion Formation during the Discussions..............................................................14
Discussion ..............................................................................................................................................................................................................................17
References............................................................................................................................................................................................................................20
Introduction

Environmental Planning can be considered as the construction and evaluation of projects for future and thus uncertain and changing environmental systems. To reach a good decision in environmental planning usually represents an ill-defined problem (cf. Scholz, Flückiger et al., 1997). One task of a planner is to accurately judge the impacts that particular variables have (Faludi, 1987; Selman, 1992). Judgments on impacts often are the basis for decision making in environmental planning. Human expert cognition provides the most reasonable and valid solutions and judgments in such ill-defined problems because of its profound flexibility (Mieg, 2001; Winograd & Flores, 1986). An adequate curriculum that prepares students for participation in environmental planning processes has to consider the corresponding requirements (Kaufman & Thiagarajan, 1987). Instruction in environmental science should enable students to acquaint a flexible knowledge base that is applicable to a variety of different ill-defined problems. To measure this capability is of course difficult. However, an improvement in the quality of students’ judgments concerning major impacts within an environmental system indicates a better understanding of the system and thus corresponds to an improved environmental problem solving ability (Scholz, Flückiger et al., 1997).

In the present study, three forms of instruction, namely, participation in a case study, group discussions, and group discussions that include the disclosure of expert judgments, will be analyzed with respect to their effects on the accuracy of students’ judgments. The judgmental tasks that were used in the experiment do not have exact solutions that are objectively correct. Therefore, the judgments of experts will serve as the point of reference for the accuracy of students’ judgments. Improvements in the accuracy of students’ judgments on environmental impacts, defined by the deviations from expert judgments are considered as the criterion for learning effects. The three different instructional formats and our hypotheses with respect to the corresponding learning processes are explained in the following.

Case Study Participation

The experiment took place in the context of the ETH-UNS case study 1998 (ETH stands for Eidgenössische Technische Hochschule [Swiss Federal Institute of Technology Zurich], UNS stands for Umwelt Natur- und Umweltsozialwissenschaften [Natural and Social Science Interface], the chair that is responsible for the management of the ETH-UNS case studies). ETH-UNS case studies are environmental projects for urban and regional development in Switzerland (Mieg, 2000). In their eighth semester, as part of their curriculum the students of Environmental Sciences at ETH Zurich altogether participate in a case study. These case studies have a strong practical orientation. They involve cooperation with scientists, municipal authorities, citizens, professionals, and representatives from various companies (e.g. Mieg, 1996; Scholz, Bösch, Mieg & Stünzi, 1997). Combining practical application of knowledge, collaboration with experts, research, and teaching, the ETH-UNS case studies set forth
a new type of *instructional design* (Gagne & Briggs, 1974; Reigeluth, 1983) and are also denoted as *transdisciplinary* activities (Häberli, Scholz, Bill & Welti, 2000). The educational aim is to improve the environmental problem solving ability of the students, to enhance their cognitive competence when it comes to mastering complexity, to improve their ability to cooperate in teams, and to enlarge their practical experience in transdisciplinary work (Oswald & Scholz, 1999; Scholz & Tietje, 2001). However, the ETH-UNS case studies serve more than an educational purpose. They also support the ecological problem solving process within the specific case, and thus, promote sustainable development. At the end of each case study a report on the environmental system that was analyzed is accomplished. These reports serve as an informative decision aid for the administrators that are involved in corresponding planning processes (e.g. Scholz, Bösch, Carlucci & Oswald, 1999; Scholz, Bösch, Stauffacher, & Oswald, 2000). The ETH UNS case study 1998 concerned problems of the socio-economical and environmental development in Klettgau, a rural region straddling the Swiss-German border. In accordance with the instructional aim of the case study it was expected that the accuracy of students’ judgments concerning major impacts within the socio-ecological system of Klettgau would increase during the case study. An improvement of judgment accuracy concerning these impacts at the end of the case study, in comparison to the accuracy at the beginning, is likely to reflect a better, more elaborate understanding of the socio-ecological situation in the Klettgau region. An enhanced understanding of the interrelationships within an environmental system, in turn indicates an improved environmental problem solving ability.

**Group Discussion**

Environmental planning today often takes place in planning groups that combine experts, politicians and citizens. For example, on a local level decisions concerning environmental planning are made in *round table discussions* and so-called *focus groups* (Kasemir et al., 1997; Krueger 1988). The dominance of group decisions in environmental planning results from the complexity and transdisciplinarity of environmental problem solving processes, as well as from the multiplicity of stake holders and interest groups that are effected by the decisions. Group discussions are a valuable means for the integration of information. This integration can comprise the exchange of knowledge from different disciplines, as well as information exchange concerning different interests or preferences.

There seem to be two main reasons why group discussions should be included in a curriculum concerning environmental planning. The first reason results from the fact that group discussions represent a common setting in professional processes of environmental planning. Therefore, it appears important to enable students to gain practical experience in environmental discussions. The second reason results from the exchange of information that takes place during group discussions. During group discussions students can acquire knowledge from different scientific disciplines in an integrative way, which can lead to a better transdisciplinary understanding of environmental systems and thus improve the en-
environmental problem solving ability of the students. One possibility of learning within group discussions consists in a process of each group member teaching his knowledge to all other group members. If the discussants exchange their information fully, this process can result in an even distribution of knowledge within the group, on a higher level than before the group process. Whereas, this process of mutual instruction does not obtain an increase in the total of the unique knowledge that is available to the group as a whole, such improvements can be obtained in process of mutual interaction that enhances individual competence interpersonally (Hackman & Morris, 1975). Process gains which add to the total knowledge of the group might, for example, be reached if the group members elaborate their knowledge together, or if they inspire each other to reach creative solutions (Osborn, 1957). Such a process represents a creative form of learning.

The group discussions in this field experiment concerned judgmental tasks. In the following a short summary is given on how group discussions can change judgment accuracy. There are two main sources of influence that determine the opinion formation process in discussions, namely normative influence and informative influence (Crott & Werner, 1994; Deusch & Gerard, 1955; Stasser & Davis, 1981). Normative influence includes conformity pressure, social desirability, and social comparison processes (e.g., Asch, 1956; Goethals & Zanna, 1979). In collective opinion formation, normative influence can have strong effects. Accordingly, opinion changes are often directed in favor of majority or plurality opinions (Crott & Werner, 1994; Crott, Werner & Hoffmann, 1996; Godwin & Restle, 1974; Hastie, Penrod & Pennington, 1983; Kerr, 1981; Penrod & Hastie, 1980; Stasser & Davis 1981; Stasser, Kerr, & Davis, 1989). However, the size of opinion factions does not account for all processes within collective opinion formation. Informative influence is also effective during opinion formation processes. Informative influence is connected to the exchange of arguments and task relevant information that takes place within group discussions (Burnstein & Vinokur, 1973, 1975, 1977; Vinokur & Burnstein, 1974). For example, in intellective tasks group members who support the correct solution can be more influential than advocates of a wrong solution (Laughlin, 1980; Laughlin & Ellis, 1986). Consequently, dynamic analyses of the opinion formation process during discussions on a variety of tasks revealed that informative factors have considerable influence. Examples are analyses of opinion formation processes by means of the Probabilistic Model of Opinion Change Including Distance (PCD model) for judgmental tasks (Crott, Grotzer, Hansmann, Mieg & Scholz, 1999), inductive problem solving (Crott, Giesel & Hoffmann, 1998), knowledge questions and logical problems (Hansmann, 2001). However, in these studies the weight of informative influence often proved to be rather small in comparison to the weight of the faction size factor. A main reason for this result might be that during group discussions the validity of the information that is voiced can be difficult to assess for the group members (cf. McGrath, 1984; Steiner, 1972). Especially, if the correct solution is difficult to demonstrate, and if the group members have no access to objective information from outside of the group, then it can be hard for the discussants to find out which arguments and opinions are valid, and which are not.
Nevertheless, studies have shown that, in a variety of tasks, group judgments are on the average more accurate than individual prediscussion judgments (for reviews, see Gigone & Hastie, 1997; Hastie, 1986). The opinion formation process during discussions usually comprises a convergence of individual opinions that corresponds in its direction to the resulting group judgment. Accordingly, improvements in accuracy have also been observed from individual prediscussion to individual postdiscussion judgments (e.g., Hansmann, 2001; Sniezek & Henry, 1990). Thus, previous research suggests that improvements in the accuracy of individual judgments will also be observed during the group discussions in the present field experiment. However, in those experimental discussions where the expert opinions have not been disclosed to the group, the lack of any informational input from outside of the group was expected to limit the instructional gains during these discussions.

**Group Discussion Including Information on Expert Judgments**

Psychological research has shown that the assignment of expert roles in a group has a great impact on the exchange of information within group discussions. Group members primarily exchange, and thus acquire, the knowledge of assigned experts (Stewart & Stasser, 1995; Stasser, Stewart & Wittenbaum, 1995). Moreover, previous research has shown that the influence of communication on opinions largely depends on the credibility of the communicator (e.g., Aronson, Turner, Carlsmith & Merrill, 1963; Hovland & Weiss, 1951). It can be assumed that experts in general possess high credibility (Mieg, 2001). Therefore, it was expected that if the discussants are informed directly on the judgment of experts, they would tend markedly to change their judgments into the direction of the expert judgment. However, there exist different ways how the information on expert judgments might cause the students to change their own judgments:

The first possibility represents a simple adoption of the expert judgments within a process of social orientation (Asch, 1956; Goethals & Zanna, 1979; Festinger, 1954; Sherif, 1935). Social orientation might cause the students to revise their own judgments due to the high credibility of the expert judgments. The group members might believe that the experts have a greater competence to make accurate judgments than they have themselves. Consequently, they might presume the expert judgments to be more accurate than their own judgments and accordingly adopt these judgments. In this case informative considerations are the basis for conformity with the expert judgments.

The second possibility comprises opinion changes due to pure normative influence (Deutsch & Gerard, 1955). Group members might hesitate to expresses judgments or arguments that differ from the expert judgments, if they fear that such arguments or judgments are evaluated negatively by others. On the opposite it might appear to be socially desirable to support the expert judgments verbally. Hence, the exchange of information during the discussions might be systematically biased. In addition, conformity pressure might operate in favor of the expert judgments to unite the opinions within a group. Such unification is
necessary to enable joint group actions, joint decisions or joint judgments, and conformity thus prepares group locomotion (Festinger, 1950). The disclosed expert judgments are fixed and unchangeable, and might be recognized by the group members as the most prominent goal of group locomotion. Moreover, it seems possible that this rigidity of the expert judgments can itself increase the influence that the expert judgments exert on the group members (Moscovici & Faucheux, 1972).

The third possibility how the information on expert judgments might promote corresponding changes of students’ estimates represents a purely informational influence. The disclosure of expert judgments might enhance the search for information that is consistent with them. If a student prefers a judgment that differs from the expert judgment he might experience cognitive dissonance. On the one hand he might have trust in the competence of the experts, and consequently in the correctness of the expert judgment. On the other hand, his information and arguments support a different judgment. This comprises a cognitive contradiction. Hence, according to Festinger (1957), the student will try to obtain cognitive consonance to balance his cognitive system. In this case there exists no possibility to change the expert judgment. Hence, cognitive consonance can only be reached by changes within the cognitive system itself. It can be achieved for example by the search for new information and by the generation of new arguments in favor of the expert judgment, or by devaluing arguments that object the expert judgment. A corresponding connection between cognitive dissonance, and processes of information seeking was supported in a number of studies (see Festinger, 1964; Frey, 1986). Analogously, the expert judgment can be viewed as evidence that contradicts the assumptions of the students. Therefore, from the perspective of Gestalt psychology the contradiction between the arguments of the students on the one hand, and the expert judgment on the other hand can stimulate productive thought (Duncker, 1935; Wertheimer, 1944, 1945). The possibility to influence the generation of arguments via feedback on the opinions of other persons was also confirmed in an experiment of Burnstein and Vinokur (1975). Burnstein and Vinokur concluded: “...that knowledge about others’ preferences can be a sufficient condition for revising preferences to the extent that it leads one to think of arguments in support of the courses of action others have selected, arguments which previously had not come to mind (1975, p. 423)."

To distinguish which types of influence on opinion formation might have been operative during the discussions of the present experiment, three corresponding, mediating hypotheses were developed:

In case of the first explanation, if the students superficially adopted the expert judgments due to their credibility, it was expected that the opinion changes into the direction of the expert judgments would be very obvious, and that these changes would take place rather fast (see Cecil & Willging, 1993).
In the case of normative influence being operative, it was assumed that the judgments of the students would gradually and continuously approach the expert judgments in the course of the discussions. This was expected, as previous research showed that normative influence is effective during all phases of a group interaction process (Crott & Werner, 1994; Crott et al. 1999; Stasser & Davis, 1981).

The third type of explanation, which comprises the creative generation of new thoughts and arguments, similarly implies a gradual approach of the students’ judgments to the expert judgments. However, in this case a considerable gain in subjective confidence concerning the correctness of the judgments was expected. Previous research using a variety of tasks showed that group discussions are often accompanied by an increase of confidence that the group members have in the correctness of their answers (Roth, 1994). Moreover, the consideration of additional information was also shown to be connected to an increase of subjective confidence (Oskamp, 1965). Therefore, according to the third explanation a marked increase in confidence was expected during the group discussions because of a mutual support of credible expert judgments and self-generated information. Contrarily, if the expert judgments are only superficially adopted, though they deviate from the original, autonomous estimates of the students, then no marked increase of subjective confidence can be expected, because the cognitive disagreement of the students with the expert judgments is not resolved during the group process (cf. Sniezek, 1992).

Method

Task and Experimental Context

The experiment was part of the ETH-UNS case study 1998 (Scholz, Bösch, Carlucci & Oswald, 1999) that focused on regional development in the Swiss-German border-straddling region of Klettgau. This rural area is situated in the peripheral agglomeration of Zurich, shows a rapid development, and serves as an important groundwater reservoir. Today, the groundwater is threatened by anthropogenic nitrate emissions caused by agriculture. The ETH-UNS case study 1998 supported the cooperation of the Swiss-German public administration, and the European Union Regional Groundwater Protection Program Interreg II (see Regli, Roth, Biedermann, Pabst & Scholz, 1998) in order to find solutions for the groundwater problem and to foster sustainable regional development.

To establish an integral perspective on the problems of the Klettgau region the students worked in four different synthesis groups (Mieg, 2000) that investigated the socio-ecological situation in Klettgau from the perspective of mobility, protection of the environment, settlement planning, and economy. These four synthesis groups worked quite independently from each other during the case study. However, in the final stage of the case study process a synthesis of their perspectives was intended.
The experimental task for the students was to judge the strength of the impact that certain environmental and socio-economical variables exerted on other variables. They were told that their estimates should refer to the situation in the Klettgau region. The following four impact relations (IR) had to be judged:

IR 1 = the impact of nature protection on the Swiss-German coordination of regional development planning,
IR 2 = the impact of support for local economy on local nature protection,
IR 3 = the impact of nature protection on the regions’ attractiveness for tourism, and
IR 4 = the impact of the Swiss-German coordination of regional development planning on the regions’ economic situation.

These impact relations were selected out of a larger list of potential impact variables that was compiled in collaboration with environmental scientists. Only four IRs were chosen because time constraints restricted the duration of the experimental sessions to one hour. In accordance with previous experiences (Crott et al., 1999) the timing with four IRs seemed to be optimal to ensure that important information could be exchanged during the discussions. Two criteria formed the basis for the selection of the impact relations for the experiment. There supposed to be some variation in the strength of the four impacts, and they had to leave room for controversial argumentation.

**Procedure and Experimental Design**

The participants of the study were 80 male and female students of Environmental and Natural Science at ETH Zurich in their eighth semester. These students were working together in a case study project that was part of their study curriculum.

The experiment as a whole consisted of two experimental runs. The basic experimental procedure was identical for the two runs. The first run of the experiment was conducted, when the students started to work on the case study. The second run of the experiment was conducted about four months later, shortly before the end of the case study. In the two experimental runs, 16 (in run 1) and 12 (in run 2) five-person groups discussed the selected impacts. The reduction in the number of groups resulted, because in the first run of the experiment more students decided to participate than in the second run, while group size was held constant in both runs. In both runs of the experiment, the groups had to discuss each of the four impact relations IR 1 to IR 4. At the end of each discussion a joint group estimate for

---

1 In environmental planning, identification of powerful impact variables and determination of influences these variables exert on other variables can serve as the basis for the performance of a computational scenario analysis. Scenario analysis is a means for strategic planning that was developed by Rand Corporation in the 1950s and 1960s (Kahn & Wiener, 1967). It is a prominent technique for environmental planning in ETH-UNS case studies because it achieves knowledge integration via fast data aggregation and thus, allows to model complex processes (Scholz & Tietje, 2001). Scenario analysis is also used in other domains e.g., for traffic planning (Forschungsverbund Lebensraum Stadt, 1994) and for predicting climate change (Houghton, Jenkins & Ephraums, 1990).
the IR under consideration had to be formed. Table 1 shows the experimental design. In both runs an experimental variation was included that consisted in the disclosure of the expert judgment for two of the four IRs in half of the groups. In the corresponding groups, the expert judgments were revealed, before the beginning of the group discussion on the task, but after each group member had already noted the individual prediscussion judgment on his or her experimental sheet. As Table 1 shows, there was no disclosure of the expert judgments for IR 1 and IR 2 in the first run of the experiment. In run 1, the expert judgments were only disclosed in half of the groups for IR 3 and IR 4. In run 2, the expert judgments for IR 1 and IR 2 were disclosed in half of the groups, whereas the expert judgments for IR 3 and IR 4 were disclosed to all groups at the beginning of the discussions. In both runs, the impact relations IR 1 and IR 2 were always discussed prior to the impact relations IR 3 and IR 4. This sequence was determined to avoid irritations that might have resulted if participants would have received the expert estimates for the first two impact relations, but would not have received these judgments for the following impact relations that they had to discuss. Therefore, only the sequence of discussions on IR 1 versus IR 2 and IR 3 versus IR 4 was balanced within the experiment.

**Table 1.** Design of the overall study including 4 months of participation in the case study (longitudinal analysis) and two runs of group discussions with an experimental variation of the disclosure of expert judgments.

<table>
<thead>
<tr>
<th>Formation of groups, ( n_{Gr} = 16 )</th>
<th>Run 1: Discussion of the 4 Impact Relations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control condition, ( n_{Gr} = 8 )</td>
<td>IR 1, IR 2, IR 3, IR 4</td>
</tr>
<tr>
<td>Experimental condition, ( n_{Gr} = 8 )</td>
<td></td>
</tr>
<tr>
<td>Disclosure of expert judgments before group discussion</td>
<td></td>
</tr>
<tr>
<td>IR 1 and 2:</td>
<td>No</td>
</tr>
<tr>
<td>IR 3 and 4:</td>
<td>No</td>
</tr>
</tbody>
</table>

4 months of participation in the case study

<table>
<thead>
<tr>
<th>Formation of new groups, ( n_{Gr} = 12 )</th>
<th>Run 2: Discussion of the 4 Impact Relations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control condition, ( n_{Gr} = 6 )</td>
<td>IR 1, IR 2, IR 3, IR 4</td>
</tr>
<tr>
<td>Experimental condition, ( n_{Gr} = 6 )</td>
<td></td>
</tr>
<tr>
<td>Disclosure of expert judgments before group discussion</td>
<td></td>
</tr>
<tr>
<td>IR 1 and 2:</td>
<td>No</td>
</tr>
<tr>
<td>IR 3 and 4:</td>
<td>Yes</td>
</tr>
</tbody>
</table>

**Note.** IR 1 = Impact of Nature protection on the Swiss-German coordination of regional development planning; IR 2 = Impact of Support for local economy on local nature protection; IR 3 = Impact of nature protection on the regions’ attractiveness for tourism; IR 4 = Impact of the Swiss-German coordination of regional development planning on the regions’ economic situation; \( n_{Gr} \) = number of five-person groups. Group discussions with experimental variation of the disclosure of expert judgments are printed boldly.

In each run of the experiment the participants were assigned randomly to the different conditions. There were four experimental sessions in run 1, and three experimental sessions in run 2. In every experimental session, four groups worked parallel, in separate rooms. The experimental sessions of each run were conducted on one single day. At each experi-
mental session 20 persons participated. They were randomly assigned to four five-person groups that were guided to separate rooms by an experimenter. There, the experimenter read aloud the instruction and then, presented the first IR to the group. Before the group discussion of an IR, the group members were given 2 minutes to individually judge the strength of the impact under consideration. Group members were supposed to mark their private prediscussion estimate on a rating scale, reaching from 1 = very low impact, 2 = low impact, 3 = medium impact, 4 = strong impact to 5 = very strong impact. In this period of individual work on the task, participants also had to allocate 100 points of confidence on the five possible impact levels according to how likely they thought that each of these levels might represent the correct impact level. Hence, the points that a person allocated to his or her own judgment can be interpreted as a measure of the confidence in its correctness (Sniezek, 1992). After denoting the individual prediscussion judgment and allocating the 100 confidence points, the group members began to discuss the strength of the IR. The discussion time was 6 minutes for each impact.

During the discussion, every 90 seconds an acoustic signal sounded. This signal requested the group members to mark on a five point rating scale the impact estimate that they most favored at this point of time, and to distribute 100 points of confidence among the five alternatives. The participants were instructed not to let themselves be irritated by these signals. Instead, they were told to continue the group discussion with the least interruption that is possible, after having denoted their current opinions. At the end of 6 discussion minutes, the group members denoted their final estimates, and once more distributed 100 points of confidence among the five alternatives. Then, the group was asked to formulate a joint group judgment for the strength of the impact under consideration. This group estimate finished the work on the first task. The experimenter then presented the next IR to the group.

The basic experimental procedure was the same for all four tasks and for both experimental runs. If, according to the experimental plan, the expert judgment for a task had to be disclosed to the group, the experimenter additionally informed the participants about the mean judgment that independent experts had made for the task. The participants received this information after they had denoted their private prediscussion judgment for the task, but prior to the beginning of the group discussion on a task. When the fourth task was finished, the experimenter answered any questions about the purpose of the research, and thanked the students for their participation. Figure 1 gives a schematic description of the experimental procedure.

---

2 Introducing this procedure of periodic opinion documentation was necessary for a detailed analysis of the opinion formation processes. Previous studies in which the effects of similar procedures that required the participants to document their opinions periodically were analyzed showed no substantial influence of these procedures on the opinion formation processes during group discussions (Crott & Werner, 1994; Kerr, 1981, 1982; Werner, 1992).
The expert estimates for the four IRs were obtained from three independent experts, who were familiar with the situation in the Klettgau region. None of these experts was directly involved in the case study. For each impact, the mean of these three estimates was considered as the expert estimate and served to determine the accuracy of the students’ estimates. The experts gave the following mean judgments ($M_{\text{Exp}}$) for the impacts on a five point rating scale reaching from 1 = very low impact to 5 = very strong impact: $M_{\text{Exp}}$(IR 1, impact of nature protection on the Swiss-German coordination of regional development planning) = 1.7, $SD_{\text{Exp}} = 0.58$; $M_{\text{Exp}}$(IR 2, impact of support for local economy on local nature protection) = 2.3, $SD_{\text{Exp}} = 1.53$; $M_{\text{Exp}}$(IR 3, impact of nature protection on the regions’ attractiveness for tourism) = 3.3, $SD_{\text{Exp}} = 1.15$; $M_{\text{Exp}}$(IR 4, impact of the Swiss-German coordination of regional development planning on the regions’ economic situation) = 1.7, $SD_{\text{Exp}} = 0.58$.

In the experiment the students, like the experts, rated the IRs on a five point rating scale that only allowed for the use of integers. Therefore, the students could not hit the mean expert judgments for the IRs exactly correct. The judgments on the five point rating scale that came closest to the mean expert judgments were the integers 2, 2, 3, 2 for the impact relations IR 1 to IR 4. This means that the minimum of the absolute deviation (DE) of students’ judgments from the expert judgment was $DE_{\text{Min}} = 0.3$ for all IRs.

**Figure 1. Basic procedure of the group discussions concerning the Impact Relations.**

- Presentation of the first Impact Relation
- Phase of individual work on the task (2 min.)
  - Assessment 1: Individual pre-discussion judgments
- Experimental variation:
  - Disclosure of expert judgment (yes vs. no)
- Start of group discussion
  - Observation interval (90sec)
  - Assessment 2: Individual judgments, subjective certainty
  - Group discussion (90sec)
  - Assessment 3: Individual judgments, subjective certainty
  - Group discussion (90sec)
  - Assessment 4: Individual judgments, subjective certainty
  - Group discussion (90sec)
  - Assessment 5: Individual judgments, subjective certainty
  - Group discussion (90sec)
  - Assessment 6: Group judgment
- Presentation of the second (third and fourth) Impact Relation following the same procedure.
Results

Firstly, a longitudinal analysis focuses on how the accuracy of the students’ individual estimates changes during the time of their case study participation. Secondly, an experimental analysis of the opinion formation process during the group discussions examines how the disclosure of expert judgments influences the process of judgment formation.

Accuracy of Students’ Judgments at the Beginning and at the End of Case Study Participation (Longitudinal Analysis)

The students participated in two group discussions on each IR. As described previously the first discussion took place at the beginning of the case study (run 1), and the second discussion at the end (run 2). In both experimental runs, the students individually estimated each IR before the start, and at the end of the group discussion of that IR. The resulting four times of measurement (M 1 to M 4) are represented in this analysis by the two repeated measurement variables discussion (2 levels: before vs. at the end of the group discussion) and case study (2 levels: at the beginning vs. at the end of the case study). The absolute deviation of students’ judgments from the expert judgment for a task will be considered as a measure of judgment (in-)accuracy. As was mentioned in the method section, the students were divided into four synthesis groups during their case study work. The students within each synthesis group cooperated closely during the case study. Hence, a statistical analysis on the basis of the group means of the synthesis groups was performed to obtain (partly) independent observations. There was of course mutual interaction taking place between the different synthesis groups during the case study. This was necessary to achieve an integrative perspective on the case. Therefore, the processes within the different synthesis groups depend on each other to some extent. However, in a longitudinal study of this type complete independence of observations can not be obtained.

The mean deviation of the individual judgments of the students in each synthesis group from the expert judgments will be the basis of this longitudinal analysis. This deviation was calculated for each task at the four different points of measurement M 1 to M 4:

M 1 = Immediately before the start of the group discussion at the beginning of the case study,
M 2 = At the end of the group discussion at the beginning of the case study,
M 3 = After four months of work in the case study, immediately before the start of the group discussion at the end of the case study,
M 4 = At the end of the group discussion at the end of the case study.

For the impact relations IR 1 and IR 2 the expert judgments were not disclosed in any group in the first experimental run at the beginning of the case study. The expert judgments for these two IRs were only disclosed in half of the groups during the discussions in the second run. This means that only for M 4 students’ judgments exist for IR 1 and IR 2 that are influenced by the disclosure of the expert judgments. Therefore, the judgments in M 4 that are influenced by the disclosure of expert judgments will not be considered here. Accord-
ingly, with respect to IR 1 or IR 2 this longitudinal analysis only considers group discussions where no expert judgments were disclosed. Complementary, for the impact relations IR 3 and IR 4, the discussions of the first run which where not influenced by the disclosure of expert judgments immediately after M 1 will not be included in this analysis. Accordingly, the disclosure of expert judgments at the beginning of the discussions (yes vs. no) is totally confounded with the use of different tasks (IR 3 and IR 4 vs. IR 1 and IR 2) in this analysis. Yet, as a consequence there is no confounding between the variable case study (before vs. after) and the disclosure of expert judgments for IR 1 and IR 2. This allows for a proper examination of the effects of case study participation itself, which is the focus of this longitudinal analysis.

An ANOVA was performed with the repeated measurement variables case study (2 levels: beginning vs. at the end of the case study), discussion (2 levels: before vs. at the end of the discussion), disclosure of expert judgment (2 levels: yes vs. no, this variable is confounded with the two tasks IR 3 and IR 4 vs. IR 1 and IR 2), task number (2 levels: high vs. low number, this variable distinguishes IR 3 vs. IR 4 on the yes level of the variable disclosure of expert judgment, and IR 1 vs. IR 2 on the no level). The dependent variable was the mean deviation (DE) of the students’ judgments in each synthesis group from the expert judgments.

The ANOVA showed a significant main effect for the variable case study, $F(1, 3) = 19.41, p < .05$. The students’ judgments at the end of the case study were significantly more accurate as the judgments at the beginning of the case study. In addition, there was a significant main effect of discussion, $F(1, 3) = 12.21, p < .05$. At the end of the discussions the students’ judgments were significantly more accurate compared to the beginning of the discussions. Figure 2 depicts the development of the mean deviation of the students’ judgments from the expert judgments over the four pre- and postdiscussion measurements M 1 to M 4 for a special selection of groups. Corresponding to the experimental design as depicted in Table 1, for IR 1 and 2 only the groups without disclosure of expert judgments are included ($M_{DE,M1} = 1.15, M_{DE,M2} = 1.00, M_{DE,M3} = 0.79, M_{DE,M4} = 0.67$), whereas for IR 3 and IR 4 only the group discussions with disclosure of the expert judgments are included ($M_{DE,M1} = 1.14, M_{DE,M2} = 0.86, M_{DE,M3} = 0.97, M_{DE,M4} = 0.66$). It seems worth noticing that according to Figure 2, there was no difference between the two IRs for which the expert judgments were disclosed, and the other two IRs in the overall tendency of the individual judgments to approach the expert judgments. No stringent conclusions can be drawn from this result, because differences of the IRs may be responsible for the two different processes, which are depicted, resulting in a similar final accuracy of the judgments. However, Figure 2 indicates that the processes of case study participation, simple group discussions, and group discussions with disclosure of expert judgments go into the same direction. The apparent rebound effect of diminishing judgment accuracy during case study participation for the IRs 3 and 4, were the expert judgments have been disclosed in the discussions of run 1, might be due to the forgetting of the disclosed expert judgments during the case study. As stated previously the impact relations used in this study were not subject of explicit instruction during the case study.
Influence of the Disclosure of Expert Judgments on Opinion Formation during the Discussions

The process of opinion formation in the experimental group discussions was analyzed with respect to changes in the accuracy of the students’ judgments, and with respect to the level of confidence that the students had in their judgments. As described, the experiment was conducted in two experimental runs. The groups were randomly formed in the first experimental run, as well as in the second one. Therefore in the following analyses, the groups of both runs are considered as independent groups, though they were formed from the same pool of persons. The experimental design only includes the group discussions on IR 3 and IR 4 in run 1 and the discussions on IR 1 and IR 2 in run 2. For these discussions the disclosure of the expert judgments was experimentally varied. In half of the groups the expert judgments were revealed at the beginning of the group discussions. In the other half of the groups, the experimenter did not reveal the expert judgments. Within this experimental design no confounding exists of the independent variable disclosure of expert judgment (yes vs. no) with any other variable.

As in the previous analysis, the absolute deviation of the students’ judgments from the expert judgment for a task was used as the measure for judgment (in-)accuracy. The units of this analysis were the five-person groups. The individual judgments for each IR were assessed five times during the discussion. Accordingly, an ANOVA with the repeated meas-
urement variables *assessment* (5 levels: individual judgments 1 to 5) and *task number* (2 levels that represent IR 3 vs. IR 4 in run 1, and IR 1 vs. IR 2 in run 2) was performed. There were two independent variables. The first independent variable was the *disclosure of expert judgment* (2 levels: yes vs. no). The second independent variable was *experimental run* (2 levels: run 1 vs. run 2). The group mean, of the absolute deviation (DE) of the individual judgments from the expert judgment served as the dependent variable.

![Deviation of Students' Judgments from Expert Judgments in the Course of the Experimental Group Discussions](image)

**Figure 3.** Mean deviation of students’ judgments from expert judgments at the individual assessments before the discussions and during the discussions, and for the group judgments, separated for the experimental groups with versus control groups without disclosure of the expert judgments. In the disclosure condition the students were informed about the expert judgments immediately after the individual assessment before the discussions.

The ANOVA showed a highly significant main effect of assessment, $F(2.98, 71.52) = 10.96, p < .001 (\varepsilon = .75)$. This effect reflects that the inaccuracy of the judgments continuously decreased from $M_{DE,1} = 0.96$ at the beginning of the discussions to $M_{DE,5} = 0.81$ at the end of the discussions. Additionally there was a highly significant interaction effect between the independent variable disclosure of expert judgment and the repeated measurement variable assessment, $F(2.98, 71.52) = 6.11, p < .001 (\varepsilon = .75)$. This effect shows that the students estimates in the groups where the expert judgments were disclosed, approached these judgments more strongly than in the control groups. Figure 3 depicts the mean inaccuracy of the individual judgments at the five individual assessments, and the inaccuracy of the group judgments, separated for the *disclosure* groups and the control groups.

---

3 Because of a significant violation of the sphericity assumption (Mauchly Sphericity Test, $p < .001$), the degrees of freedom were corrected according to the Huynh-Feld-Epsilon ($\varepsilon = .745$). A similar procedure was necessary in some of the following analyses. Values of Huynh-Feld-Epsilon are presented in parentheses after the level of significance.
The effect of the disclosure of expert judgments on the accuracy of students’ judgments was analyzed in more detail using single contrasts of the disclosure X assessment interaction. A significant disclosure X assessment effect concerning judgment accuracy was observed between the first and the second individual assessment, $F(1, 24) = 6.86, p < .05$. The second individual assessment was obtained only 90 seconds after the disclosure of the expert judgment for an impact. This means that up to this point, the students had only 90 seconds time to generate and to exchange arguments supporting the expert judgment. It appears plausible to assume that at least to some extent they superficially adopted the expert judgment during this period. The process of simply taking over the judgments of the experts can take place quickly. This process might thus only have been influential during the first 90 seconds. There was a marginally significant disclosure X assessment interaction contrast in the second discussion period between the second and the fourth individual assessment, $F(1, 24) = 3.46, p < .1$. This effect indicates that the participants in the disclosure condition generated information supporting the expert judgments and thus, obtained a higher increment in their understanding of the IRs, as compared to the members of the control groups. However, because at the beginning of the discussions the group members in the experimental condition tended to adopt the expert judgment, at the subsequent stages of the process conformity pressure might have been operative in the same direction. Thus, at least to some extent, normative influence can also account for this result.

In addition to the individual estimates, the group members had to formulate a common group judgment for each task. The group judgments were not included in the previous ANOVA, because individual learning is the main focus in the present context. However, an additional analysis revealed that the accuracy of the group judgments in the experimental condition with disclosure of the expert judgments was not higher than in the control groups (see Figure 3). This was due to a marginally significant increase in accuracy from the last individual judgments to the group judgments in the control groups ($p < .1$), which was not observed in the experimental condition.

Similarly to the analysis of judgment accuracy the subjective confidence (C) of the students in their judgments was also analyzed within an ANOVA that included the repeated measurement variables assessment (5 levels: individual judgments 1 to 5) and task number (2 levels that represented the two different tasks that were included in this ANOVA for each experimental run). The independent variables were disclosure of expert judgment (2 levels: yes vs. no) and experimental run (2 levels: run 1 vs. run 2). The group mean of the confidence points that each group member allocated to his or her own judgment served as the dependent variable.

The analysis showed a significant main effect of assessment, $F(3.40, 81.54) = 3.61, p < .05$ ($\varepsilon = .85$). Before the discussions the mean confidence level was $M_C = 58.16$, after 90 seconds of discussion the mean confidence level was reduced to $M_C = 57.15$, subsequently the confidence level increased continuously to $M_C = 59.67$ at the end of the discussions. The dis-
Effects of Group Discussion, Expert Information, and Case Study Participation on Judgment Accuracy

Discussion

This field experiment analyzed the effects of three forms of instruction, namely participation in an environmental case study, group discussions on the relationship between environmental impact variables within a system, and the disclosure of corresponding expert judgments. Changes in the accuracy of students’ judgments on environmental impacts, as measured by changes in the deviation of these estimates from the corresponding expert judgments, were interpreted as an indicator for learning effects. The ETH-UNS case study 1998 in Klettgau presented the context for these analyses. However, it is assumed that the results that were found hold true for judgmental processes in all contexts where non-experts start to get acquainted with a complex system that might be best understood by experts.

The longitudinal analysis revealed a significant effect of case study participation on judgment accuracy. This increase in judgment accuracy is interpreted as an indicator for an improved environmental problem solving ability, which students obtained during participation in the case study. The strength of the experimental evidence for this interpretation is of course not perfect. A weakness of the longitudinal analysis is the lack of a control group. It was neither possible to exclude half of the students from participating in the case study, nor was it possible in any other way to contrive a comparable control group. Thus, changes in the estimated impact levels might, for example, have also been caused by objective changes of certain conditions in the Klettgau region during the time of the case study. Moreover, the collaboration with experts during the project work in the case study is naturally connected to the reception of expert judgments on relevant aspects of the problem under consideration. Yet, it is important to note that the impact relations that were selected for the experiment have not been the focus of any planned instruction during the case study. Therefore, it is not very likely that during the case study the students were confronted directly with the judgments of experts on the selected impact relations. Also, the experts, whose estimates served as the standard of excellence for the students’ judgments in the field experiment, did not take part in the case study.

The experimental subdesign compared the process of collective judgment formation in groups, where the expert judgments were disclosed at the beginning of the group discussions versus in groups where no such disclosure took place. As expected, the net effect to reduce the deviation of the students’ judgments from the expert judgments was stronger in the discussions where the expert judgments had been disclosed to the students. However, there was no difference between the accuracy of the common group judgments of the experimental versus control groups. This was due to the fact that only in the groups without disclosure of expert judgments the group estimates were more accurate than individual
judgments immediately before this judgment was formed. It seemed as if in the groups with disclosure of expert judgments at the beginning of the discussions there was at the end of the discussions no potential left for the group judgments to obtain a higher accuracy than the individual judgments immediately prior to these decisions. The lack of differences in the deviation of the group judgments from the expert judgments between the experimental and control groups indicates that in the condition with disclosure of expert judgments the groups did only take over these latter judgments to the point which their independent reasoning supports.

However, another result was that in the disclosure condition the subjective confidence that the students had in their judgments did not increase during the discussions, whereas there was such an increase in the control groups. This result is to some extent conflicting with the previous statement because we considered gains in confidence of the participants in the disclosure groups to indicate a real understanding of the expert judgments, as opposed to a superficial adoption of these judgments. The direction of the corresponding marginally significant disclosure X assessment interaction effect was surprising. Experts generally possess a high credibility, which we assume to be one reason for the strong influence that the expert judgments exerted on the students’ judgments. It might well have been expected that the disclosure of information from a highly credible source would be connected to a high confidence of the students in their own adapted judgments. One explanation, for the obtained marginally significant disclosure X assessment interaction with respect to group members’ confidence might be the confrontation with disagreement. As Sniezek (1992) showed, the confrontation with a great diversity of different judgments lowers the confidence of group members in their individual judgments in the first phase of a group discussion. This effect can be supposed to be stronger in the disclosure groups, because the confrontation with the expert judgments tends to increase the overall range of different judgments to be considered. Moreover, the experts could not contribute arguments to support their judgments. Such arguments would have increased supposedly the confidence of the students who adopted the position of the experts. A second explanation bases on the distinction between an analytic and an intuitive mode of thinking (Bastick, 1982; Hammond, Hamm, Grassia & Pearson, 1983; Scholz, 1987). As Bastick (pp. 21) states, the analytic thinking does not result in a feeling of certainty, as it is devoid with feeling. In contrast, intuitive thinking elicits a feeling of certainty. Accordingly, Hammond et al. (p. 9) differentiate between confidence in the product of thinking, and not in the methods, as in intuition, and confidence in the methods, but not in the product, as in analytic thought. A comparison between the process of collective judgment in the disclosure condition and in the control groups with respect to attributes of intuitive versus analytic thought (Scholz, 1987) indicates that the process in the disclosure groups is more analytic than in the control groups. According to Scholz, two important features of intuitive thinking are the preconscious acquisition of information and the dependence on personal experience. In the control groups the group members construct their judgments in an isolated group process. This process can be assumed to dependent on personal experience to a large extent. On the other hand, in the
disclosure groups, the information on expert judgments is an influence that is independent of the personal experience of the group members. Therefore, the process in the latter groups is probably less dependent on personal experience. On the basis of a similar reasoning, it can be concluded that the process of information acquisition in the disclosure groups is more conscious than in the control groups. Thus, it appears reasonable to assume that the process of collective judgment in the disclosure groups is more analytic than in the control groups. This might be a reason for the lack of an increase in the group members’ confidence in the disclosure groups.

In summary, considering the results concerning judgment accuracy and individual confidence no definite conclusion can be drawn as to which extent the students really understood the expert judgments that had been disclosed to them, and to which extent they simply adopted superficially the expert judgments, e.g. because of their high credibility. Therefore, it is difficult to decide which of the two discussion formats obtains a stronger learning effect with respect to the students’ environmental problem solving ability, even though there was a stronger net effect on individual judgment accuracy in the disclosure groups. Group discussions in higher environmental education should probably use the advantage of both experimental conditions, that is on the one hand independent group discussion, and on the other hand, information on expert judgments. A possible advice for the design of an instructional group discussion is to begin with an autonomous group discussion without the disclosure of expert opinions. This first part of the instructional group discussion could increase the accuracy of individual judgments concerning environmental impacts and improve the students’ understanding of an environmental system. Moreover, during this part of the instructional group discussion the students can acquire practical experience in a discussion that is quite similar to those occurring in professional environmental planning. An autonomous joint group judgment should mark the end of this first discussion phase, because this procedure would structure the instructional group discussion as a whole, and because group judgments are often connected to an increase in judgment accuracy (Gigone & Hastie, 1997). After the autonomous group judgment the expert judgments should be disclosed to the students, as an additional informational basis for the second part of the instructional group discussion. In this second part of the instructional group discussion a further increase in the congruence of the students’ estimates with the expert estimates might be obtained. During this second part of the instructional discussion the reasoning and the arguments of the experts for their judgments should also be unveiled to the students. This would enable the students to better comprehend the expert judgments, to gain confidence in these judgments, and to subsequently form a group judgment on a more elaborate informational basis. The principle of this instructional procedure is to give the students an opportunity to construct their own viewpoint or opinion, and in a further step to improve these opinions by means of a more direct form of instruction that consists in the presentation of additional information. Thus, the students can first try themselves, and subsequently look for a valid check of their results.


UNS-Working Paper 5 (Out of Print)


UNS-Working Paper 6 (Out of Print)

UNS-Working Paper 7 (Out of Print)


UNS-Working Paper 8 (Out of Print)


UNS-Working Paper 14 (Out of Print)


UNS-Working Paper 15

UNS-Working Paper 16 (Out of Print)
Jungbluth, N. (1997). Life-cycle-assessment for stoves and ovens. 5th SETAC-Europe Conference, Reij, & G. Steiner (Eds.), Towards sustainable land use (pp. 53–66). Reiskirchen: Catena.)

UNS-Working Paper 17

UNS-Working Paper 18

UNS-Working Paper 19 (Out of Print)


UNS-Working Paper 20

UNS-Working Paper 21

UNS-Working Paper 22 (Out of Print)


UNS-Working Paper 23 (Out of Print)


UNS-Working Paper 24

UNS-Working Paper 25

UNS-Working Paper 26 (Out of Print)


UNS-Working Paper 27

UNS-Working Paper 28

UNS-Working Paper 29

UNS-Working Paper 30