

# Teachers' Investigation of Students' Self-Perceptions Regarding Physics Learning and Problem-Solving

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**Abstract.** Transfer is required in nearly every activity of problem solving. It spans from transferring procedures within a finite set of similar “end of the chapter problems” to applying problem solving strategies in completely unfamiliar problems. Students' self-perceptions, in the context of problem solving and learning, influence the success of instruction promoting transfer. Hence, teachers have to attend to such self-perceptions. We conducted a cooperative inquiry workshop to support teachers who modify their instruction in problem solving to better achieve transfer goals. As part of the workshop, the teachers raised the need to develop a questionnaire examining students' self-perceptions in the context of problem solving and learning in physics. The development of the questionnaire was supported by educational research, in a manner reflecting the teachers' motivation and time limits. In this paper, we describe the process of developing the questionnaire, present findings from a validation analysis of the questionnaire, and discuss its role in the teachers' professional development.

## INTRODUCTION

Transfer is required in nearly every form of problem solving. It spans from transferring procedures within a finite set of similar “end of the chapter problems” to applying problem solving strategies in completely unfamiliar problems.

Students' self-perceptions regarding learning [1,2] and problem solving in physics, as well as their self-esteem [3], affect their responsiveness to instruction intended to develop transfer skills. For example, teaching systematic problem solving search strategies might be rejected by students who expect to engage in a fast, linear process for solving a problem, or by those who expect to search for the solution in a random manner [4]. Therefore, teachers who modify their classroom practice towards transfer goals need to address students' self-perceptions that were shaped in former and significantly different practice.

This issue troubled the participants of a teachers' workshop that focused on innovative ways to develop students' transfer skills in physics problem solving [5]. During the workshop, the participants initiated the development of a questionnaire to examine students' self-perceptions in areas related to the workshop theme. In this paper we describe the workshop context, how the workshop participants raised the need to study students' self-perceptions and the ways in which teachers and researchers cooperated in the

development process. Then we examine the validation of the questionnaire and discuss how the development and analysis of such a questionnaire may help teachers to address students' self-perceptions.

## DEVELOPING A QUESTIONNAIRE

Eight physics teachers participated in a year-long cooperative inquiry workshop. The teachers customized to their classrooms PER-based instructional materials designed to develop transfer skills in physics problem solving [6]. The instructional approach was characterized by explication and reflection on problem-solving processes used by experts. For example, students were required to explicitly present steps of a problem-solving strategy in their solutions, or, with guidance, to self-assess their test solutions.

A cooperative inquiry was carried out to ensure teachers' active involvement. It consisted of rounds in which each of the teachers, in turn, presented in a computerized forum an activity that had been tried out in the classroom. Next, a discussion was held with all participants to explore answers to questions raised by the presenters [5].

In the course of the workshop, the teachers repeatedly initiated a discussion about differences in students' learning styles, in their self-images and in

their perceptions of learning. In the discussions a large spectrum of classifications was suggested. Teachers classified students according to their achievements as "strong" and "weak" as well as by personality traits.

For example, Teacher A raised the following question for discussion: *"There is a group of students who do not speak up in class. How can self-diagnostic activities be exploited to cause them to express themselves?"*

One of his colleagues, B, answered, *"A silent student is not necessarily a passive or weak student. There are those who think but do not express their thoughts, and those whose silence expresses lack of thinking and withdrawal from the lesson. The self-diagnosis activity can activate the passive student. It is worthwhile to cause the students to 'defend' their diagnosis. Maybe this can be promoted through a discussion between pairs of such students?"*

Teacher C raised the question, *"Why, in your opinion, were the weak students more critical with themselves in the diagnosis than the others?"*

Her colleague, D, answered: *"Self-diagnosis of one's own mistake influences self-confidence: on the one hand, learning from a mistake empowers; on the other hand, there are students who cannot accept failure and fall into a situation of denial or desperation."*

The teachers suggested that different traits of the students may interact (e.g. diagnostic ability with self-confidence; being withdrawn with passiveness or with low academic achievement, etc.). Following these discussions, the teachers suggested the preparation and administration of a questionnaire for students in order to characterize those traits that are relevant to the new teaching methods offered by the workshop.

There are a variety of research tools in the educational literature that can serve teachers in developing such a questionnaire. These tools examine traits such as learning styles (e.g. self-regulation, persistence, responsibility for studying); self-images (e.g. capability, anxiety) [7,8,9]. Since the workshop participants were neither acquainted with the literature, nor had time to explore it, both mediation and compromise were required. The workshop leader (a researcher in the field of science teaching) and the teachers collaboratively developed the questionnaire in several stages, taking different roles:

1. **The teachers** determined the structure and content of the questionnaire. They agreed on a 24-statement, self-reporting Likert-type questionnaire and proposed areas in which they wished to characterize their students: a. persistence; b. organization; c. cooperative work; d. reflectivity; e. concentration; f. self-confidence; g. anxiety; h. external vs. internal motivation; i. responsibility for learning; j. planning.

2. **The leader** imported resources. A pool of about 200 statements was gathered from relevant questionnaires found in the educational research literature.
3. **The teachers** constructed the questionnaire, selecting relevant statements from the aforementioned pool.
4. **The leader** prepared the preliminary version of the questionnaire.
5. **The teachers** pilot-tested the questionnaire with their students (N=139).
6. **The leader** revised and tuned the questionnaire through factor analysis.

This statistical analysis identified six highly-correlated groups of statements (factors). Two statements that did not pass the customary correlation threshold (0.35) with any grouping were sifted out. When the statements of each factor are considered together they characterize a certain personality trait. A group of experts was asked to describe and name each of the factors. The group included the workshop leader, a teacher-researcher, a workshop participant, a high-school principal and two physics curriculum developers. Differences were discussed until agreement was reached. The various experts chose almost identical names for each factor and clarified the identity of each factor. Statements from the questionnaire appear in Table 1.

**TABLE 1.** Factors in the general population.

<p><b>Factor 'A': The persistent, self-regulated searcher:</b></p> <ol style="list-style-type: none"> <li>1. I try different approaches until I reach the solution.</li> <li>7. When I have difficulty in solving a problem, I search for the point where I went wrong.</li> <li>11. I try to find a connection between what we learned in class and what is written in the book.</li> <li>12. (marginal) I ask myself questions on the material we just learned in order to ascertain that I understood it.</li> <li>20. I don't leave the problem until I find a solution to it.</li> <li>22. When I approach a problem, I plan what I am going to do.</li> </ol>
<p><b>Factor 'B': The determined student:</b></p> <ol style="list-style-type: none"> <li>13. I am confident about my ability to meet the requirements of the subject of physics.</li> <li>17. What I am learning in physics is important to me.</li> <li>21. A high grade in physics is very important to me.</li> </ol>
<p><b>Factor 'C': The self-confident student:</b></p> <ol style="list-style-type: none"> <li>10. I am confident of my ability to understand whatever they teach me in physics class.</li> <li>13. I am confident of my ability to meet the requirements of the subject of physics.</li> <li>14. I am very worried about exams (-).</li> <li>15. Eventually I will always be able to find a solution, even to difficult problems.</li> <li>18. I feel stressed when I have to work in an unfamiliar way (-).</li> </ol>
<p><b>Factor 'D': The student striving to improve:</b></p> <ol style="list-style-type: none"> <li>2. I check my work to ascertain that I have done it correctly.</li> <li>5. I prefer to learn systematic approaches to problem solving,</li> </ol>

<p>rather than just practicing by solving many problems (-).</p> <p>9. Sometimes in class, or while doing homework, I start thinking about other things (-).</p> <p>19. If I don't do well on an exam I try to learn from my errors.</p>
<p><b>Factor 'E': The self-securing student:</b></p> <p>3. When I am studying for an exam I prepare a list for myself of the important points in the material.</p> <p>16. When I encounter a difficulty, the first thing I do is to ask the teacher for help.</p>
<p><b>Factor 'F': The individualist:</b></p> <p>4. When I get a hard problem I try to solve it together with a friend (-).</p> <p>6. Studying can only be done alone because teamwork interferes with the pace of personal progress.</p> <p>8. I don't ask many questions in class so as not to disturb the course of the lesson (-).</p>

The (-) sign represents opposite polarization

## VALIDATING THE QUESTIONNAIRE

How valid is this instrument? The content validation was achieved through the process of developing the questionnaire. We studied the construct and criterion validity of the questionnaire via a) analysis of sub-samples; b) comparison of students' answers in the questionnaire to students' achievements in an activity developed by the workshop teachers.

### Content Validation

The questionnaire was constructed by teachers in response to a need they had raised. Thus it reflected the teachers' conception of relevant student traits. The consensus in the group of experts on the meaning of the various factors constitutes additional content validation of the questionnaire.

### Construct Validation

The following analysis was carried out on the improved version of the questionnaire using a sample of 15 classes (N=352). First, a factor analysis was carried out on the whole sample (see Table 1 showing the titles (in italics) and statements of each factor). Second, factor analyses were carried out on several sub-samples defined through various criteria (e.g. sex, class level, etc.). Then, the factors obtained for the whole sample served as a reference set and were compared with those obtained for the particular sub-sample in the following manner: for every factor in the whole sample, factors were sought in the partial sub-sample that almost coincided with it. The differences between the composition of factors in the whole sample and in the sub-samples were interpreted and judged on the basis of the relevant literature. As an

example, we present two analyses carried out for the sub-samples of boys (N=245) and girls (N=101).

- Factor A includes statements 1,7,11,20 for the boys and statements 1,2,(-)5,16,20,22 for the girls. The girls' factor differs significantly from the original A factor in the whole sample. Instead of reflective statements (7, 11) one gets the hard work and self securing statements (2,(-)5,16).
- Factor C includes the original statements for the boys and statements 10,12,13,(-)14,15,20 for the girls. Statements 12 (assuring understanding) and 20 (persistence) are added to the girls' factor.

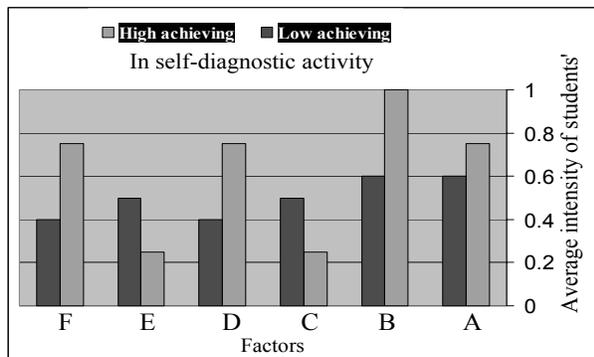
That is, for the girls, the "persistent, self regulated searcher" factor transforms to the "persistent, hard working and self-assuring searcher" factor, and the self-confidence factor is associated with a determined approach to studying and to solving problems. These results are consistent with those reported by Sroufe et. al. [10] who claim that parents, teachers and even boys and girls themselves attribute high achievements by girls in mathematics to hard work, whereas those of boys are attributed to talent. If a girl has self-confidence in her ability to meet the requirements of the subject, and to solve even difficult problems without fear, it is not taken for granted and "natural" as it is with boys. The girl demands from herself a commitment to reach the solution. To summarize, the findings in these sub-samples are in accord with the developmental theories regarding differences between boys and girls. These results contribute to the construct validity.

### Criterion Validation

The teachers expected that the students' actual achievements in an activity requiring transfer would correlate with the students' profile of traits. We focused on one activity, developed by a teacher, to study the relationship between students' traits and their achievements. The activity dealt with self-diagnosis of a problem solution on an exam. The students had to identify the execution of central stages in the problem solution (description, definition and presentation of sub-problems, checking the answer), and to pinpoint mistakes in the application of the relevant principles of physics. The teacher carried out the activity in his class. We developed a rubric to assess students' achievements in self-diagnosis. The rubric judged students' achievements in locating, categorizing, explaining and correcting mistakes. The teacher administered the questionnaire and characterized the students' profiles. A "profile" stands for the distribution of intensities of the various factors. Since the sample was small (n=10) the profile averages were calculated for high and low achievers in the self-

diagnostic activity (Table 2). It was found that the low achievers had higher intensity of the factors "C-self-confident" and "E-self-securing". These findings correspond to the teacher's expectation that students who are very confident and students who believe that they work "by the book" would have a lesser tendency to diagnose themselves. These findings contribute to criterion validation of the questionnaire.

**TABLE 2.** Students' Profiles vs. Achievements



## DISCUSSION AND SUMMARY

This paper describes a workshop in which teachers attempted to promote transfer in problem solving by their students. They realized the importance of students' traits, in realms such as self-efficacy and self-monitoring, to their goal. The teachers suggested designing a questionnaire that would allow them to identify relevant student traits. The teachers cooperated with researchers in developing the questionnaire: The researchers imported resources from the professional literature, while the teachers judged the relevance of these resources to their practice. In constructing the questionnaire, the teachers set aside academic achievements and focused on learning practices, perceptions and attitudes.

The questionnaire can serve the professional development of teachers by enabling them to reformulate and sharpen their intuitive distinctions regarding traits of students in the following ways: a) The questionnaire reflects an agreement between the teachers regarding which student traits are relevant to fostering self-monitoring in solving problems; b) the factor analysis develops a common and well-defined professional language; and c) this professional language can be used to discuss and address traits of students that affect transfer in problem solving.

To summarize, the construction of the questionnaire can raise teachers' awareness to relevant traits of their students and lead towards student-centered teaching. The findings of this study suggest

that: a) Students' profiles, as defined by the factor analysis, are correlated with students' achievements in problem-solving activities requiring transfer. b) Findings from studying the composition of factors in sub-samples (e.g. boys vs. girls) are in accord with theory. These findings contribute partially to the validation of the questionnaire and justify using it as a professional development tool.

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