PROBLEM-BASED LEARNING AND INTRINSIC MOTIVATION

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INTRODUCTION

In current research on intrinsic motivation two themes can be distinguished. The first focuses on the effect of extrinsic rewards on intrinsic motivation (Deci 1971; Lepper & Greene 1975; Morgan 1984). The second deals with the relationships between instructional methods, intrinsic motivation and achievement (Bloom 1976; Johnson & Johnson 1979; Steinkamp & Maehr 1983). Our paper can be situated in the second line of research.

A serious obstacle in reviewing the literature on intrinsic motivation, is the fact that different terms are in use referring to more or less the same phenomenon. Intrinsic or continuing or cognitive motivation, subject-related affect or attitude or interest, epistemic curiosity: when looking at the various measures no clear demarcation can be found. Deci (1975, p. 23) defines intrinsically motivated activities as ones for which there is no apparent reward except the activity itself. The activities appear to be ends in themselves rather than means to an end: they bring about certain kinds of internal states which are found rewarding. In a more educational context, Fransson (1977) defined intrinsic motivation as a state where the relevance (perceived value) for the learner of the content of the learning material is the main reason for learning. The learning content can be rather specific, such as: the Battle of Gettysburg, or rather general e.g.: history. When knowledge in general is positively valued, terms such as epistemic curiosity and cognitive motivation are used.

It is interesting to note that without specification the term intrinsic motivation is not very informative. There exists no intrinsic motive like one speaks of an achievement motive or power motive. When someone informs us that person A is intrinsically motivated, this may mean that person A is interested in geography or Playboy, or anything else for that matter. Although the term 'interest' with a specification (e.g. interest in history, or in the Civil War) would be a very accurate and sufficient substitute for all other terms, we too will use the other terms as they have become such popular labels in psychological publications.

When summarizing various large-scale studies, Bloom (1976) found an average correlation of about .31 (about .10 higher when corrected for attenuation) between affect toward a school subject and achievement in that subject. Correlations were slightly lower in the primary school period and for literature and reading, while correlations were slightly higher in the high school period and for science, mathematics and second language. Bloom also reports a number of small, experimental, and school-based studies contrasting mastery learning approaches with more conventional approaches. Interest in a learning task, at the beginning of that task, and achievement at the end of the task correlated about .30 (.38 after correction for unreliability). It was also found that in the mastery groups interest in the subject tends to increase, while in the control groups interest tends to remain the same or even decline. Bloom concluded that achievement and affect are interrelated or that one influences the other in a kind of spiral effect. Thus, high achievement (or more exactly: perceived high achievement) increases positive affect.

According to Bloom, the evidence reported in concurrent, predictive, longitudinal and experimental studies is consistent in suggesting that affect is a causal link in determining learning and in accounting for educational achievement. In Bloom's view, affect helps to determine the extent to which the learner will put forth the necessary effort to learn a specific learning task, i.e. how hard (intensity) and how long (persistence) the learning will be. Bloom proposes that subject-related affect should be altered (i.e., increased) by implementing teaching, curriculum and grading policies in the school which stress high ratios of success experiences to failure experiences.

Johnson and Johnson (1979) report that there is evidence that epistemic curiosity can also be sparked by other means than success experiences. Controversy among students or between the students and the teacher can be used to create conceptual conflict and epistemic curiosity within students. Controversy exists when one person's ideas, information, conclusions, theories or opinions are incompatible with those of another person, and the two seek to reach an agreement.

Conceptual conflict has high arousal potential, motivating attempts to resolve it by seeking new information or by trying to reorganize the knowledge one already has. The greater the disagreement among students or between the teacher and the students, the more frequently the disagreement occurs, the greater the number of people disagreeing with a student's position, the more competitive the context of the controversy, and the more affronted the student feels, the greater the conceptual conflict the student will experience (Johnson & Johnson 1979).

Smith, Johnson and Johnson (1981) compared controversy, concurrence seeking and individualistic learning. All three types of learning begin with students categorizing and organizing their present information and experience so that a personal conclusion is derived. In individualistic learning the student becomes fixed and satisfied with the information he has. Within concurrence seeking, there is a suppression of different conclusions, an emphasis on quick compromise, and lack of disagreement. New information that may challenge the conclusions is avoided. In controversy the students realize that others have a different conclusion, become uncertain about the correctness of their own conclusion, and actively search for more information. Students actively represent their position and reasoning to the opposition, thereby engaging in considerable cognitive rehearsal of their position and its rationale. In their search for a more adequate cognitive perspective, students listen to and attempt to understand conclusions and rationale of other students. The results of Smith, Johnson and Johnson (1981) indicate that controversy, compared with concurrence seeking and individualistic study, promotes higher achievement and retention as well as continuing motivation.

Controversy learning is strikingly similar to an instructional method called problem-based learning, which is increasingly used in health professions education (Schmidt & De Volder 1984). Students are confronted with a problem, i.e. a real-life phenomenon (e.g.: a case of A.I.D.S. after a blood transfusion) in need of some kind of explanation. The task of the students is to formulate possible explanations, then to search additional information, and finally to discuss the different viewpoints and try to understand the underlying mechanisms of the phenomenon studied. Problems are supposed to make the students "hungry for knowledge" (Barrows 1984, p. 24). So far, however, research evidence is lacking for this assumption.

While it has been shown that intrinsic motivation can be generated by educational methods such as mastery learning and controversy learning, it is less clear whether there is a causal link from intrinsic motivation to school achievement. As described earlier, Bloom (1976) concludes that affect influences achievement. Steinkamp and Maehr (1983), however, suggest that it is primarily the acquisition of proficiency that leads to positive attitudes: one is most likely to feel positively toward science as one actualizes one's ability through science achievement. The conclusions of Steinkamp and Maehr are based on the following pattern of correlations. Mean correlations between achievement and cognitive ability in science are significantly positive for high school boys ($r=.36$) and girls ($r=.32$). The relationship between achievement and science-related affect is small but significant: for males the mean correlation is .19 and for females .18. Although it would seem that students with the ability to do science would like science, in which case data on cognitive ability and science would be strongly related, the synthesized studies showed that the expected relationship does not exist for boys or for girls (r=.07 and .02, respectively). Confronting Bloom with Steinkamp and Maehr, it seems safe to conclude that controversy exists with respect to the causal nature of the relationships between ability, affect and achievement.

METHOD

Our research focuses on two questions: First, can intrinsic motivation be generated by the problem-based learning method; and second: which causal relationships exist between ability, motivation and achievement?

Subjects

Subjects were 69 female and 15 male first-year students from four schools of allied health. The average age was 18,6 years with a standard deviation of 13 months.

Procedure

Subjects from each school were randomly assigned to the experimental or the control condition. In the experimental (problem-based learning) condition, seven groups of about six students were formed. In each of these groups a male experimenter was present. He briefly explained the problem-based learning method by means of a written example consisting of a plant releasing oxygen in a bright environment but not in a dark environment. In a hand-out of one and a half pages, the phenomenon was analysed from a few viewpoints and a number of more or less elaborated explanations were offered. The experimenter actively involved subjects to check their understanding of the way they were to proceed with the next problem. He emphasized that they were to brainstorm about possible explanations for the problem and to analyse the explanations offered by discussing them with each other. This briefing took five to ten minutes. The experimenter then announced that the problem-analysis discussion should not take longer than fifteen minutes, and the problem was given in writing. It read: "A red blood cell is placed in pure water. Under the microscope we can see it swells very quickly and finally bursts. Another blood cell is placed in salt water and begins to shrink." When subjects have finished reading the problem, the discussion starts. The experimenter acted as discussion leader: asking questions, paraphrasing answers and summarizing. It was essential that, while leading the discussion, he did not provide new information. This was verified by audiotaping the discussion.

In the control condition, four groups of about 11 subjects were formed. Subjects in these groups were instructed to write down - individually - everything they remembered about osmosis within fifteen minutes. After the experimental and control episode, all subjects received a sheet with the following question: "I am interested in knowing more about osmosis." They were asked to indicate their opinion on a five-point scale from "not at all" (point 1) to "very much" (point 5). Then, all subjects were given a text of six pages on the topic of osmosis. The text contained no formulas, tables, figures, or other didactic features in order to avoid interference between conditions and text features. Subjects were instructed to study the text during 15 minutes. After 15 minutes of text study, subjects were told how the experiment would carry on. Since no time limits were set for the next phases, each subject was allowed to raise his hand after completion of a phase and to proceed with the next phase. When this was clear to the subjects, they received a booklet (the free-recall test) with three blank pages and a front page with the following instruction: "Write down everything you remember about the text on osmosis. Write sentences and do not use a telegram style or drawings." When the subjects felt they did not remember anything more than they had already written down, they were give a second booklet. The second booklet contained a completion test consisting of 44 items related to the text on osmosis. Some examples of items are: "Diffusion proceeds quicker when molecules are .... (answer: smaller), and: "When two concentrations possess the same maximum osmotic pressure, they are called .... (answer: isotonic). Alpha reliability of the completion test was calculated at .73.

Inter-rater reliability for counting the number of correctly recalled propositions, calculated for a number of randomly selected free recall protocols, was 90% and higher.

In addition, the biology grade received in the final examinations of the last year of secondary education (i.c. approximately 6 months before our experiment) was recorded from the school files.

DATA ANALYSIS AND RESULTS

Means and standard deviations of all variables are shown in Table 1. Pearson intercorrelations between all variables are shown in Table 2.

Table 1. Means and standard deviations of the following variables: previous achievement in biology (Biology), intrinsic motivation (Motivation), free recall (Recall) and test achievement (Test) (n = 84)

	Mean	S.D.
Biology	6.50	0.85
Motivation	2.80	0.77
Recall	55.02	34.72
Test	31.15	4.12

Table 2. Pearson correlations between previous achievement in biology (Biology), experimental (code 1) versus control (code 0) condition (Condition), intrinsic motivation (Motivation), free recall (Recall) and test achievement (Test) (n = 84)

	1	2	3	4	5
1. Biology	1	.14	.13	.04	.23
2. Condition		1	.24	.01	.11
3. Motivation			1	.12	.15
4. Recall				1	.07
5. Test					1

A t-test for independent samples (experimental versus control group) was carried out on the data obtained from the question on interest in osmosis.

In the experimental group the mean interest score (2.98) was significantly higher ($t=2.23$, $df=82$, $p=0.03$, two-tailed) than in the control group (mean score of 2.61).

Structural relations between the research variable were analysed with multiple regression techniques (Kenny 1979). In the first multiple regression, intrinsic motivation served as criterion, and two predictors were used. The experimental condition was scored "one" versus the control condition "zero". This dummy variable (problem based learning versus individual activation of prior knowledge) served as first predictor. The second predictor was biology grade. In the second multiple regression, the completion test score was used as criterion, and intrinsic motivation, the experimental versus control condition and biology grade served as predictors.

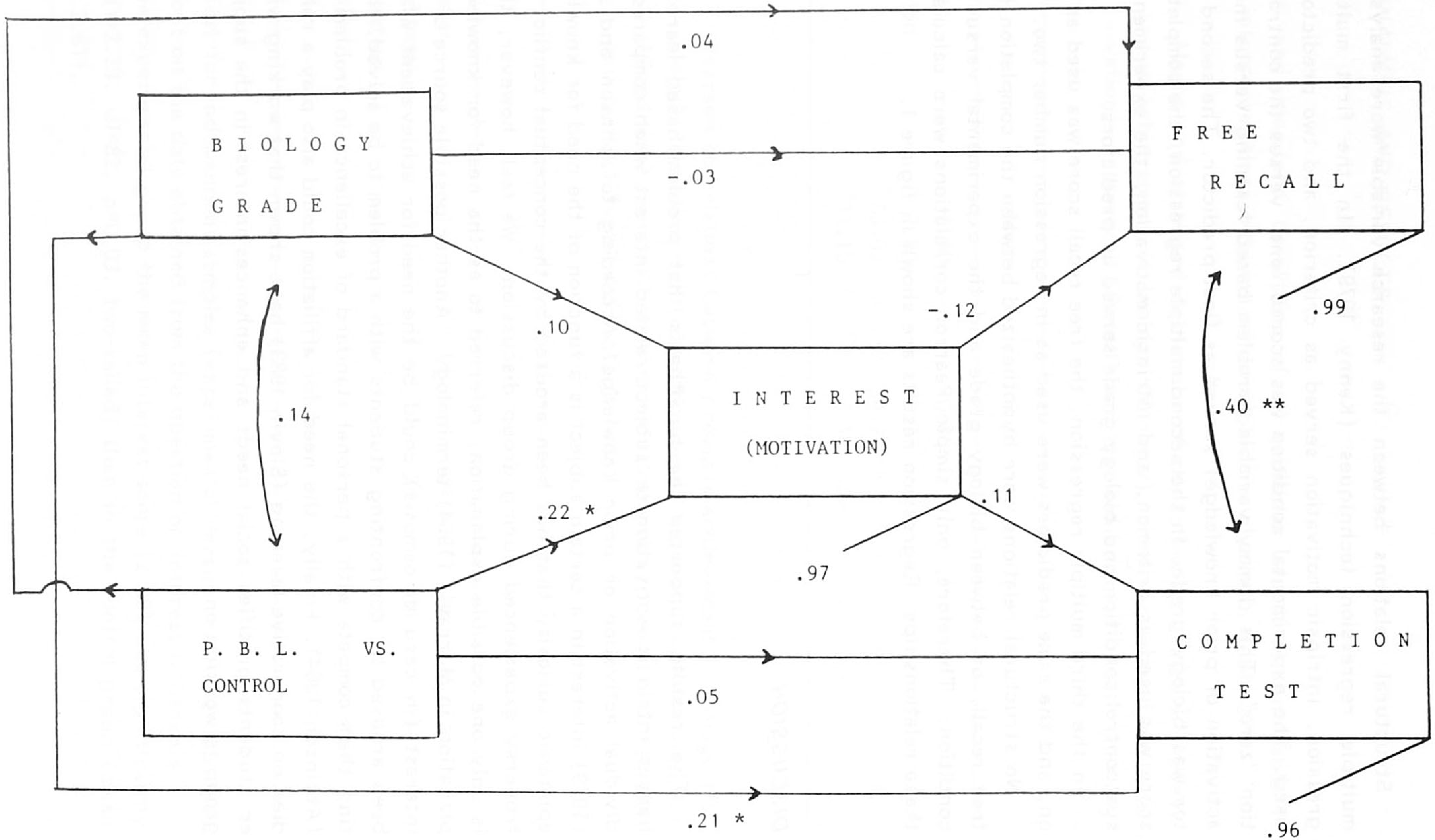
In the third multiple regression, the free recall score was used as criterion, and the same predictors were used as in regression number two.

No structural relations were hypothesized between the completion test and free recall, or between biology grade and the experimental versus control condition. Therefore, only simple Pearson-correlations were calculated for these relationships. Regression results are shown in figure 1.

DISCUSSION

The results supported the hypothesis that problem-based learning enhances intrinsic motivation or subject-related interest when compared to individual activation or prior knowledge. According to Johnson and Johnson (1979) interest in a certain subject is a function of the need for knowledge or epistemic curiosity that has been aroused by the conceptual conflict or controversy experienced during group discussion. We feel, however, that this is only one possible explanation, referred to as the need for knowledge explanation in Murray's (1964) terminology. Another possible source of avowed interest (in casu in osmosis) could be the need for achievement which has been aroused by confronting students with a problem to be solved, thus letting them compete with a personal standard of excellence in problem solving (Atkinson 1964). Finally, the need for affiliation could also play a role. Studies on cooperative learning (Slavin 1983) have shown that working with other students gratifies social needs and enhances interest in the subject the group is working on.

Figure 1: Path coefficients (beta-weights) between biology grade, problem-based learning (P.B.L.) versus control condition, interest in osmosis, free recall, and completion test.
Coefficients with an asterisk are significant at the 10% level; with two asterisks at the 1% level.



In our view, these different explanations indicate the difficulty of operationalizing the theoretical concept of intrinsic motivation as defined by Deci (1975). The most often used operationalization, namely letting subjects indicate their interest in or preference for a certain activity, leaves doubts about the intrinsic or extrinsic nature of the motivation involved. Let us illustrate this point referring to the three motivational explorations mentioned earlier. When interest in osmosis is a function of a generalized need to know, one could accept the conclusion that no apparent external reward is present except the activity itself of getting to know more about something. In the case of interest arisen in cooperative groups and thus based on the gratification of social needs, it could be safely argued that the social contacts constitute an external reward. Interest sparked by the achievement motive lies somewhere in between: although theoretically the standard of excellence is internal, in practice it is often dependent on the norms put forward by a group or authority figure, and thus the reward of reaching the standard of excellence becomes externally mediated.

Looking again at the definition of intrinsic motivation, it must be noted that nothing is said about the way intrinsic motivation comes about, but only about the effect of intrinsic motivation: intrinsic motivation is the causal, driving force behind certain activities. This leaves three questions. We have already addressed the first, namely: since there is no such thing as an intrinsic motive, can intrinsic motivation be defined in terms of the general need for knowledge eventually narrowed to more specific topics? As the need for knowledge satisfies the Deci definition, contrary to the needs for achievement and affiliation, as we have argued earlier, in our view the answer to this first question should be affirmative (but only, of course, with respect to intrinsic motivation for school subjects).

The second question is: how can intrinsic motivation, thus interpreted, be purely measured? We tried to do this by focusing on the knowledge aspect (I am interested in *knowing* more about osmosis), but it is in our view fundamentally impossible to maintain that this interest is purely epistemic and to exclude the possibility that this interest could also be related to the achievement and affiliation motives.

This is obvious in our experiment, but also when interest is measured in a non-experimental study, it is unclear whether interest is purely epistemic or based upon the expectations of the respondents to be able to satisfy their social or achievement needs, or even other needs. To paraphrase an old saying: intrinsic motivation is in the eye of the experimenter.

The third question is: which activities are meant in the definition of intrinsic motivation? Or put differently: if interest is a pure measure of intrinsic motivation, which activities are influenced by this interest? In our experiment, we used two activities: free recall of the text on osmosis and achievement on a completion test on osmosis. In retrospect, we doubt that these two variables are well chosen as dependent variables, influenced by intrinsic motivation interpreted as purely epistemic.[1] Curiosity leads to information gathering (e.g.: reading a book, viewing a movie, talking to a professor) and thus only indirectly and eventually to higher achievement. Free and cued recall tests do not satisfy a curiosity need, but rather an achievement need, and perhaps a score of other needs.

A better dependent variable would be time spent on studying the text on osmosis. We opted for an equal allotment of study time, because we primarily focused on the amount (intensity) of the motivation generated and not so much on the persistence resulting from this motivation. And also because, given a certain time for study, the amount of *intrinsic* motivation should have an effect upon the amount of energy spent while studying and thus upon the recall measures. In the design phase, we based this assumption on the results reported in the reviewed literature. Now, we think it is time to be more careful with the term intrinsic motivation, and we for our part view interest not only as intrinsic but as intrinsic and/or extrinsic.

More or less unwittingly, we have arrived at the second part of the discussion, focusing on the relationships between previous biology grade, problem-based learning, (intrinsic?) motivation, and subsequent achievement on free and cued recall tests. The results showed that achievement is not significantly influenced directly by problem-based learning or indirectly through the intervening variable of interest (from now on, we will omit the term "intrinsic motivation" and refer to the interest measure instead). Traditionally, the first explanation to be put forward, is sloppy research. There are contra-indications for this interpretation, however.

First, some of the involved variables do show significant relationships, indicating that these variables are not totally unreliable. Secondly, post-experimental inspections of the procedure (audio-taped discussions) did not reveal any alarming mishaps. Thirdly, where possible, reliabilities were calculated and proved to be satisfactory (see the paragraph on procedure).

Why, then, was interest not related to achievement? Although achievement is multi-determined, one would expect a small but significant relationship with interest. Its absence can have two causes. First, it is possible that the constraints of our experimental situation hindered the motivational processes normally at work. In regular school work, interest in a certain

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[1] It should be clear by now, of course, that we do not favor this purely epistemic interpretation of the interest measure.

subject can lead to a variety of extra activities leading to higher achievement.

In our two-hour experiment, we controlled all that. Also, a one-time only experiment has a very limited impact: we were able to arouse interest, but for how long and with how many consequences for effort-costly and multi-determined measures of achievement?

The second reason says just the opposite: in general interest simply does not influence achievement. Steinkamp and Maehr (1981) advocate this idea. No real explanation is offered, so we assume the parsimony hypothesis is invoked here, saying that the simplest solution is to be preferred, which is: there is no causal link. However, Steinkamp and Maehr also conclude that interest is a function of previous achievement. Our results showed no significant relationship between biology grade and interest in osmosis. Perhaps the difference in level of generality (biology versus osmosis) is a factor. But in our view, this is also an indication that the first explanation is probably the right one: it is unwarranted to have too high expectations from a limited experiment.

In conclusion, the controversy still remains, perhaps arousing interest, and perhaps even stimulating more research activities.

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