

PORTUGUESE PHYSICS TEACHERS' ATTITUDES  
TOWARDS STUDENTS' ALTERNATIVE CONCEPTIONS  
ON MECHANICS

**ABSTRACT.** The new Portuguese physics syllabuses advise teachers to base their teaching on their students' alternative conceptions. This article aims to describe Portuguese physics teachers' attitudes towards students' alternative conceptions on mechanics. Data were collected from 251 Portuguese physics teachers by means of a questionnaire prepared by the authors. The results of the present study seem to indicate that the teachers who have already acquired some background information about the issue of alternative conceptions are better prepared to deal with students' alternative conceptions on mechanics. Based on the results of this study, the authors argue for the need to improve teachers' knowledge and attitudes towards students' alternative conceptions so that they can put into practice the new syllabuses recommendation.

INTRODUCTION

The Portuguese Ministry of Education has been carrying out a reform in the educational system which includes significant changes in the school curricula and syllabuses. Nowadays, the new syllabuses are being implemented in some schools for evaluative purposes. They are to be reformulated (if evaluation shows this is needed) and to be taught to every student taking 5th, 7th, and 10th grades in 1992.

In what concerns the physical science subject (which includes physics and chemistry topics taught by only one teacher), it will keep on being taught from 8th grade onwards but more time will be allocated to it at some grade levels. However, great changes are forecast for the sequence, organization and depth of content to be taught, which can be illustrated by the case of mechanics. In the old syllabuses, this topic is first included at the 10th grade but, according to the new syllabuses, qualitative mechanics will be anticipated to the 8th grade and it will be later integrated with quantitative mechanics, at the 10th grade. Another important difference between the old and the new physical science syllabuses refers to the explicit argument included in the latter for both a constructivist perspective of learning and a teaching strategy based on students' previous conceptions, including alternative conceptions. This means that physical science curriculum planners are aware of the recent developments in science education and want physics teachers to take them into account when teaching the new syllabuses.

As the alternative conceptions theme is a recent issue in Portugal, the authors wonder whether Portuguese physical science teachers are ready to effectively teach the new syllabuses, starting from students' conceptions. The topic of mechanics seems to be particularly difficult on this respect as it is a topic on which Portuguese students (Sequeira and Leite 1991) as well as students of other nationalities (Moreno and Moreno 1989) hold several alternative conceptions. On the other hand, there is some evidence that students can have success on mechanics and still maintain their alternative ways of thinking (Sequeira and Leite 1989). This can be at least partly explained by the fact that traditional teaching has focused on quantitative mechanics. The separation of

qualitative mechanics from quantitative mechanics and the anticipation of the first one to the eight grade, may prevent students from success unless they really master the concepts which they are supposed to learn. This is only possible if adequate treatment is given to students' alternative conceptions.

This article aims to describe Portuguese physics teachers' attitudes towards 10th grade students' alternative conceptions on mechanics and to make some inference about the action needed to prepare physical science teachers to teach qualitative mechanics, according to the new syllabuses concerns.

## 1. METHODOLOGY

### A. Population and Sample

The Portuguese physical science teachers (which are approximately 3000 teachers) are the population for this study. The authors assumed that 10% of the teachers, selected randomly on a school basis, would be a representative sample of the population. This means that about 300 teachers participating on this study were needed. As data were to be collected by mail, 1000 teachers (from 120 schools) were invited to participate in the study although only 251 of them returned a valid completed questionnaire.

### B. Instrument

A questionnaire was prepared by the authors for the purposes of this study. The first version of the questionnaire was discussed with six physical science teachers, two science education and a research methods specialists. Their comments were taken into account during the preparation of the second version of the questionnaire (which would happen to be the final version). Three judges agreed with the adequacy of each question to the objective formulated. The questionnaire was then handed out to some physics teachers, to be completed under the conditions of the final study. The analysis of the thirteen questionnaires which were completed and returned has shown that no major change was required. The questionnaire was therefore considered ready for the final study. Its objectives are to enable the authors: a) to identify the percentage of teachers who have already heard about alternative conceptions; b) to compare the attitudes towards students' alternative conceptions on mechanics shown by teachers who had heard about alternative conceptions with those of the teachers who never heard about this issue. These attitudes concern the perceivableness of students' alternative conceptions during mechanics classes, the recognition of the resistance of these conceptions to teaching, the didactical treatment given (or not given) to these conceptions and the attribution of causes to students' conceptions on mechanics.

## 2. DISCUSSION OF RESULTS

Only 45% (n=114) of the physical science teachers participating in this study had heard about alternative conceptions. On the other hand, only 74% of the teachers have ever taught 10th grade mechanics. When doing so, 93% (that is 173) of them realized

that their students take to the mechanics classes some ideas which are different from the scientifically accepted ones. Although this was the designation used throughout the questionnaire (to enable all teachers who have ever taught 10th grade mechanics to answer to it in spite of the fact of having or not having heard about alternative conceptions), from now on, those ideas will be referred to as alternative conceptions on mechanics.

Table 1 shows how frequently the teachers who have already taught 10th grade mechanics perceive that their students take some alternative conceptions (which were identified by previous studies (Sequeira and Leite 1989; Sequeira et al. 1989) and seem to be relatively frequent and/or resistant ideas (Poza 1987, p. 127-130)) to the mechanics classes, comparing teachers who had heard about alternative conceptions (Group A) with those who never heard about it (Group B). Data in table 1 show that teachers who had heard about the alternative conceptions theme seem to perceive the students' alternative conceptions which were considered on this study more frequently than their counterparts who never heard about that issue. The differences between the two groups of teachers are statistically significant for alternative conceptions "A" (DF=170,  $t=2.90$ ,  $p<.005$ ), "B" (DF=170,  $t=2.37$ ,  $p<.01$ ), "D" (DF=168,  $t=2.34$ ,  $p<.05$ ), "F" (DF=169,  $t=2.79$ ,  $p<.01$ ), "G" (DF=168,  $t=2.52$ ,  $p<.05$ ), "L" (DF=170,  $t=2.34$ ,  $p<.05$ ) and "M" (DF=168,  $t=2.43$ ,  $p<.05$ ). This means that the differences between the two groups of teachers are statistically significant for seven (out of thirteen) alternative ideas, that is for more than 50% of the ideas considered on this study. (see Table 1, next page).

It is interesting to notice how high is the frequency with which both groups of teachers perceive that their students take to the mechanics classes the idea that "Heavier objects fall faster than lighter objects" (alternative conception "I"). Besides, this was the alternative conception on which teachers' answers showed both a higher index of radicality (.64, that is medium/high radicality, equal for both groups) and a higher level of consensus (.38 for teachers who heard about alternative conceptions and .40 for teachers who did not hear about the issue). This means that alternative conception "I" was the alternative conception on which teachers' answers both tended to concentrate most on the higher extreme of the scale (radicality index) and agreed most (consensus level) (Serafini-Trulls, 1991). This can be explained by the fact that this conception is not only very frequent among Portuguese students but is also very resistant to physics teaching (Sequeira et al. 1989). Although the analysis of the results in table 1 seems to indicate that teachers who had heard about alternative conceptions perceive them more frequently than other teachers do, the low level of consensus (never reaching the minimum of 0.5) existing among teachers of each group seems to indicate that the teachers in each group do not behave as a group, in relation to the perceivableness of the alternative ideas that students take to the mechanics classes. In this study it was not investigated how much teachers know about the alternative conceptions theme. However, the authors suspect that in most cases that knowledge may be very reduced. If this suspicion is true, it can possible explain the reduced level of consensus existing among teachers who had heard about alternative conceptions as well as the non existence of a statistically significant difference between the two groups of teachers, for some of the alternative ideas. Following this way of reasoning, the other group of teachers' low perceivableness and consensus may be explained by the fact that their lack of knowledge about the alternative conceptions theme makes it difficult for them to perceive their students' conceptions

Table 1:

Teachers' scoring of their perception of students' alternative conceptions on mechanics

(N = 173)

Alternative conception	Mean score*		Mode*	
	Group A	Group B	Group A	Group B
	(n=80)	(n=93)	(n=80)	(n=93)
A. Constant velocity requires constant force	3.03	2.64	3-4	3
B. Constant acceleration requires an increasing force	2.49	2.14	3	3
C. Motion requires a force acting in the same direction	2.84	2.67	3	3
D. The direction of motion changes intantaneously to the direction of the applied force	2.33	1.98	3	1
E. There is no force acting on a resting body	3.13	2.89	4	3
F. After a force stops acting on a moving body, its velocity decreases uniformly	2.95	2.55	3	2-3
G. If a force stops acting on a moving body, motion returns to its initial state	1.82	1.51	1	1
H. Inanimate bodies do not exert forces	1.98	1.86	1	1
I. Heavier objects fall faster than lighter objects	3.54	3.54	4	4
J. In vacuum, objects don't fall because there's no gravity	2.00	1.92	1	1
K. In an interaction (e.g. crash, gravity), the body having more mass and/or velocity exerts a greater force	2.91	2.83	3	3
L. Force is proportional to velocity	2.68	2.36	3	2
M. Objects have force	1.96	1.62	1	1

\*Scoring 1 - Did not perceive; 2 - Perceived sometimes; 3 - Perceived many times; 4 - Perceived every time I taught mechanics

Group A - Teachers who had heard about alternative conceptions;

Group B - Teachers who never heard about alternative conceptions;

According to the results given in table 2, teachers who have heard about alternative conceptions feel these are harder to change than teachers who never heard about that do. In fact, about 73% of the teachers from the first group have experienced that these conceptions either require special strategies or are hard to change even when using special strategies, while only about 47% of the teachers in the latter group have experienced so.

Table 2:

Teachers' experience of the difficulty in changing students' conceptions

(N = 165)

Items	Group A (n=79)		Group B (n=86)	
	f	%	f	%
	A. The traditional teaching-learning changes them definitely	2	2.5	13
B. Traditional teaching-learning changes them but some time later they will appear again	19	24.1	32	37.2
C. Traditional teaching-learning is not able to change them; This change requires special strategies	29	36.7	21	24.4
D. These ideas are hard to change even when using special strategies	29	36.7	20	23.3

Group A: Teachers who had heard about alternative conceptions;

Group B: Teachers who never heard about alternative conceptions.

When teachers were asked about whether or not they take the ideas their students bring to the mechanics classes into account during their teaching practice, only one teacher (out of 173) stated that he/she does not do it (Table 3). According to Table 3, the percentage of teachers that gave reasons to take them into account which are more related to the interference of these conceptions with the learning of mechanics (reasons C and D) is larger for the group of teachers who had heard about alternative conceptions (72.1%) than it is for the group of teachers who never heard about that issue (53.2%). Again, this may indicate that the first group of teachers is more aware of the negative effects of the alternative conceptions in the students' learning of mechanics than the latter group is.

Table 3:

Teachers' reasons for (not) taking into account students' conceptions on their teaching  
(N = 171)

Reasons	Group A (n=79)		Group B (n=92)	
	f	%	f	%
A. No; It would make students feel confused	0	0	1	1.1
B. Yes; They are a good starting point	22	27.9	42	45.6
C. Yes; They interfere with mechanics learning	12	15.2	23	25.0
D. Yes; They are a good starting point and interfere with mechanics learning	45	56.9	26	28.3

Group A: Teachers who had heard about alternative conceptions;

Group B: Teachers who never heard about alternative conceptions.

Table 4 shows the methodological procedures used by the teachers when they take into account their students' conceptions. The analysis of the data presented in table 4 shows that the percentage of teachers who "identify students' ideas", "help students to perceive the limitations and contradictions of their ideas" and "compare students ideas with the history of science ideas", is higher for the group who had heard about alternative conceptions. The differences between the two groups are statistically significant. The results of the  $\chi^2$  test (after continuity correction) are respectively:  $DF=1$ ,  $\chi^2=7.287$ ,  $p<.01$ ;  $DF=1$ ,  $\chi^2=3.83$ ,  $p<.05$ ;  $DF=1$ ,  $\chi^2=6.161$ ,  $p<.05$ . In what concerns the methodological procedure "B" (Make students aware of their ideas), the difference between the two groups is about to be statistically significant. (see Table 4.)

Although the difference between the two groups of teachers relatively to procedure "G" is also statistically significant, the importance which may be given to this fact is very reduced, due to the very low number of cases which are responsible for it. Thus, the results presented in table 4 seem to indicate that teachers who had heard about alternative conceptions tend to use procedures which make students more conscious about their ideas, about the limitations and contradictions of these ideas and which require more participation from their students in the change of those ideas. These are some of the procedures which have been advocated by several authors working on alternative conceptions and conceptual change (e.g. Driver and Oldham 1986, Posner et al. 1982). However, there are some procedures which are still used by large percentages of teachers of both groups. That is the case of procedures "C" (Demonstrate students that their ideas are wrong) and "H" (Compare them with the accepted ideas). These procedures are teacher centered and therefore the authors wonder how and how much students participate in these processes and how effective they are in changing students' alternative conceptions.

Table 4:

Methodological procedures used by the teachers with their students' alternative conceptions on mechanics  
(N = 173)

Methodological procedures	Group A (n=80)		Group B (n=93)	
	f	%	f	%
A. Identify students' ideas	43	53.8	30	32.3
B. Make students aware of their ideas	40	50.0	32	34.4
C. Demonstrate to students that their ideas are wrong	32	40.0	40	43.0
D. Help students to perceive the limitations and contradictions of their ideas	58	72.5	53	57.0
E. Advise students to test their ideas	37	46.3	33	35.5
F. Help students to evaluate the advantages of the scientifically accepted ideas over their own ideas	31	38.8	25	26.9
G. Advise students to forget them	5	6.3	0	0.0
H. Compare them with the accepted ideas	43	53.8	52	55.9
I. Compare them with the history of science ideas	31	38.8	19	20.4

Group A: Teachers who had heard about alternative conceptions;

Group B: Teachers who never heard about alternative conceptions.

Finally, teachers were asked about the contribution they think some issues may give to the existence and/or persistence of students' alternative ideas on mechanics. Data related to this question are presented in table 5.

The analysis of teachers' answers shows significant differences in relation to some of the items. Thus, teachers who heard about alternative conceptions considered that "students' everyday language", "didactic presentation of the content" and "teachers' lack of knowledge about alternative conceptions" have a significant higher contribution to students' conceptions than the other group of teachers did. The results of the t-test when applied to these three items are, respectively:  $DF=152$ ,  $t=2.936$ ,  $p<.005$ ;  $DF=152$ ,  $t=2.155$ ,  $p<.05$ ;  $DF=127$ ,  $t=3.765$ ,  $p<.0005$ .

Issues like "students' cognitive development", and "students' lack of some fundamental concepts" have a statistically significant higher contribution for teachers who did not hear about alternative conceptions than they have for teachers who have got some background information on this matter. The t-test results are respectively:  $DF=152$ ,  $t=2.24$ ,  $p<.05$  and  $DF=166$ ,  $t=2.595$ ,  $p<.05$ . It is worth noticing that item B (students' everyday observation of natural phenomena) has been scored near grade 3 of the scale by both groups of teachers, meaning that they all seem to think it can give an important contribution for the existence of alternative conceptions in students' minds.

Table 5:

Teachers' scoring of some possible causes of students' alternative conceptions on mechanics

(N = 173)

Causes	Mean score*		Mode*	
	Group A (n=80)	Group B (n=93)	Group A (n=80)	Group B (n=93)
A. Students' cognitive development	2.97	3.23	3	3
B. Students' everyday language	3.19	2.86	3	3
C. Science fiction films and books	2.56	2.44	3	2
D. Students' everyday observation of natural phenomena	3.20	2.99	3	3
E. Didactic presentation of the content	2.88	2.59	3	3
F. Teachers' lack of knowledge about the alternative conceptions theme	2.99	2.38	3	3
G. Students' lack of some fundamental physics concepts	2.74	3.05	3	3
H. Students' lack of mathematical concepts	3.03	3.11	3	3

\*Scoring: 1- No contribution; 2 - Small contribution; 3 - Good Contribution;  
4 - Main contribution

Group A: Teachers who had heard about alternative conceptions;  
Group B: Teachers who never heard about alternative conceptions.

However, teachers who have heard about the alternative conceptions theme, scored it a bit higher (3.20) than their colleagues who never heard about that (2.92). The same applies to the item about science fiction, as the first group scored it 2.56 while the latter group scored it 2.43. Although the differences between the two groups are not statistically significant, the mean scorings seem to indicate that teachers who got some background information on alternative conceptions considered these items (causes "C" and "D") are more important causes of students' alternative conceptions than the other group of teachers did. Therefore, the analysis of the results shown in table 5 seems to indicate that the group of teachers who have got some information on the issue of alternative conceptions tends to feel more responsible for their students' alternative conceptions than the first group do and to attribute more importance to some possible causes which have already been identified elsewhere (Sequeira and Leite 1990) as such. But the level of consensus among teachers in both groups is again lower than 0.5, for all the items, and some items were not scored by 11% of the teachers. This means that again, teachers in each group did not behave as a group and that some of them are not sure about whether or not some of possible causes contribute to students' conceptions.

## CONCLUSION AND IMPLICATIONS

The results of this study show that only 45% of the Portuguese physical science teachers had heard about alternative conceptions, which is a low percentage, as expected.

Despite the possible low level of teachers' knowledge about alternative conceptions, the results of this study seem to indicate that teachers who had heard about alternative conceptions show better attitudes towards their students' conceptions on mechanics than their counterparts do. In fact, the first group of teachers seems to perceive more frequently the conceptions their students take to the mechanics classes, to be more conscious about both how difficult these conceptions are to change and how they interfere with formal teaching, to use didactical procedures more likely to change those conceptions and, finally, to feel more responsible for their students' conceptions, than the other group does.

Although some of the indications of this study (e.g. those concerning didactical procedures) should be further investigated, it seems that teachers who acquired some knowledge about the alternative conceptions theme are more prone to teach mechanics according to the new syllabuses recommendation than are their counterparts who have no knowledge about it. However, it seems that the knowledge possessed by the first group of teachers is not yet enough to teach the new syllabuses, as these teachers do not yet behave as a group. To effectively teach physical science based on students' conceptions, teachers need to abandon teacher and/or content centered teaching strategies and to use student centered methodological procedures. This may be an hard task for teachers to do by themselves. Thus, they will need help and guidance from science educators and researchers in order to being able to effectively deal with alternative conceptions. Teachers may need adequate diagnostic tests, teaching materials, methodological advice, etc. However, adequate knowledge about the issue of alternative conceptions may facilitate the teachers' job and help them to deal with the challenge brought to them by the new syllabuses.

Therefore, it seems that a lot of work has to be done if teachers are to put into practice the new syllabuses and to start teaching mechanics to 8th grade students, based on their alternative conceptions. This can be done by including the alternative conceptions theme in physical science education courses and in initial training courses for physical science teachers. Also in-service courses for physical science teachers should be organized so that these teachers can acquire enough knowledge about the issue of alternative conceptions and teach mechanics at the 8th and the 10th grade level according to the new syllabuses recommendation.

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