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Student Generated Recommendations for Enhancing Success in Secondary Science and Mathematics

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One frequently overlooked approach to improving academic success is the simple technique of listening to the students. Students are uniquely positioned to understand the nature of school problems, and their perceptions can be useful in forming solutions to problems of academic failure and school leaving. In this study, science-tracked secondary school students in Portugal (*N*=346) responded to open-response questions regarding what schools and teachers can do to improve success in the 10th grade in general, and specifically in Mathematics and Physics/Chemistry. Content analysis revealed specific dimensions of student recommendations including (a) teacher strategies, (b) teacher affect and (c) curriculum. Student recommendations emphasized diversifying teaching methods, permitting greater student input, making clear connections between class material and real-life applications. Students indicated the importance of developing a positive classroom environment and urged more time for the learning of complex concepts. While their implementation may not be appropriate in all cases, student suggestions can be useful in identifying problem areas, and in some instances may offer sound advice to teachers and educational leaders. We discuss these suggestions, including just what it means to teach with a "real-life" orientation. We propose a distinction between authentic events that are learning relevant and those that are goal relevant.

Keywords: Academic Success, School Organization, Science Education; Student Perceptions, Teacher Behavior.

INTRODUCTION

Abundant empirical studies demonstrate that many students do not understand some concepts essential to science and mathematics, that they have difficulty in applying basic knowledge, and that they lack proficiency in decision making and in resolving real-life problems (GAVE-Gabinete de Avaliação Educacional, 2001, 2003, 2004; OECD-Organization for Economic and Cultural Development, 2003a, 2003b, 2004, 2006, 2007). Researchers around the world have targeted this general problem and given it high priority from an institutional and educational perspective (Abd-El-Khalick et al., 2004; American Association for the Advancement of Science, 1990; Colucci-Gray, Camino, Barbiero & Gray, 2006; Fischer, Klemm, Leutner, Sumfleth, Tiemann & Wirth, 2005; Hofstein & Lunetta, 2004; National Research Council, 1996; Roth & Désautels, 2002; Roth & Lee, 2004). Attempts at reform take place in a context of increased governmental emphasis on the importance of science and technology in modern societies (Gago, 2007).

In Portugal, student achievement, levels of understanding and application of science concepts are

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consistently described as below the average of other OECD countries (Farinheira, Fonseca & Conboy, 2005; GAVE, 2001, 2003; OECD, 2004, 2007; Pinto-Ferreira, Serrão & Padinha, 2007). At the secondary level, failure rates in science and math are especially high, most notably in the 10th grade (Carreira & André, 2000). School leaving, or dropping out, is commonplace (Aguiar, 2007; Ministério da Educação, 2008).

Many organizations, researchers and educational leaders have begun to call for systemic reforms that attack the problem of academic failure on all possible fronts, from school organization, climate and conditions, teacher training, supervision and accountability, to curriculum development (American Association for the Advancement of Science, 1990; Anderson, Brown, & Lopez-Ferrão, 2003; Fonseca, 2003; Hewson, Kahle, Scantlebury, & Davies, 2001; National Research Council, 1996; Supovitz, & Taylor, 2005). Contributions from science educators and other educational leaders have resulted in the implementation of curricular reform in Portugal (Decreto-Lei nº 74/2004 of 26 March; Miguéns, 2004).

However, whether we talk about the Portuguese approach to the problem or the global effort, seldom have the students themselves been consulted about what they see as the important changes necessary to improve academic success in science and mathematics. When student views are incorporated in research designs, strident criticisms of the teaching of science frequently emerge (Osborne & Collins, 2001; Haussler & Hoffman, 2000).

A better understanding of student perceptions can provide science educators and other educational leaders with additional information about how to increase academic success and reduce the dropout rate. As primary actors, clients and beneficiaries of the education process, students are uniquely positioned to understand the nature of school problems. It is therefore fundamentally important to understand what the students themselves perceive as the causes of school failure and to take under advisement their suggestions for action by schools and teachers.

In a previous study (Fonseca & Conboy, 2006), Portuguese secondary-school students rated a series of predefined, literature-based factors with regards to their perceived importance in academic failure in science disciplines in the 10th grade. The students highlighted poor teaching and inadequate previous academic preparation as the most important factors of failure. As part of the same project, the present study reports student-generated, open-response suggestions as to how to improve success in the sciences, both in terms of actions that should be taken by schools as well as by individual teachers.

The study of student perceptions of success and failure and student recommendations for educational reform has been limited, but promising. One approach has been to measure discrepancy between what occurs in school and what students think should occur--the perceived difference between reality and an ideal. The resulting real-ideal deficit can be useful in gauging student perceptions of pedagogical strategies that may require teacher, or school-wide, attention. Angell, Guttersrud, Henriksen and Isnes (2004) used this method in a study involving more than 2000 randomly selected Norwegian science students in grades 12 and 13. The largest discrepancies they observed between what is done and what is desired by students were the factors they termed "qualitative" and "pupil-centered" teaching methods. Students indicated they would prefer greater use of practical description for the presentation of new concepts (as opposed to mathematical presentation), and more group discussion and demonstrations to illustrate concepts. Other areas that showed a real-ideal deficit included (a) using pupils' suggestions in the lessons, (b) letting pupils choose both the problem and the method in experiments, (c) problem-solving in groups, (d) project work and (e) the use of additional literature besides the textbook. According to students, the method of the teacher presenting new material at the blackboard is used frequently in the sciences. Students indicate that they would prefer less "chalk and talk" and more class discussion as a means of making difficult subject matter more understandable.

The work of Seidel and Prenzel (2002) also supports the notion of a student preference for an expanded repertoire of teaching strategies. They studied 13 introductory physics class groups (grades 7 and 8) over the course of one school year. Students reported that, for most classes, teaching consisted mainly of transmission of concepts and demonstrative experiments. Some classes were more student centered (with periods of individual or small group work as opposed to lecture and teacher-centered questioning). When working in this context, students reported more intensive cognitive activity and more intrinsic motivation. In classes with longer periods of individual or group work, students reported more positive perceptions of teachers' support and interest, quality of instruction, learning conditions, relevance of class content, as well as social relatedness.

Angell et al. (2004) also found that students adapt--swiftly and submissively-- to the teaching they actually do receive. The authors suggest that it is sometimes difficult for the students to imagine alternatives to the teaching they receive—since they view the subject matter as fixed and the instruction methods as largely determined by the nature of the subject matter. In this Norwegian study, students acknowledged their responsibility in learning, asserting that success depended largely on their own enthusiasm and engagement. Fonseca and Conboy (2006) on the other hand, in a sample of Portuguese 10th-grade students, found that the students overwhelmingly attributed failure to factors that were essentially external to them and uncontrollable, such as teaching quality.

Many studies have pointed to the fundamental influence of the teacher on students' attitudes toward the subject matter and teaching (Corbett & Wilson, 2002; Nollen, 2003; Osborne & Collins, 2001; Sadler & Tai, 2001). But do students have preferences about teaching?

Stokking (2000) found that high school physics students, in a representative sample of schools in the Netherlands, wanted physics teaching to have a stronger orientation toward everyday life and to use methods that encouraged their active participation in class. But what is the meaning of an "everyday life orientation", and what are its consequences? Such student attitudes about an "orientation toward everyday life" have been instrumental in effecting curriculum change in some cases. Just such an approach was described by Carlone (2003) and demonstrates the pendulum effect frequently observed in curricular reforms.

Carlone describes the implementation of a reform-based curriculum (*Active Physics*), implemented in an upper-middle-class high school in the United States. The curriculum was described as activity-based, group-oriented and aimed at student interests. Its scope was considered wider than the typical, academic-oriented physics courses and was designed to appeal to a broad range of students. The curriculum placed emphasis on interesting, relevant, real-world themes and on students' involvement, participation and sharing of ideas. While analysis revealed no differences in achievement between the *Active Physics* group and traditional physics students, attitudes toward physics were considerably more positive among the *Active Physics* students. The following year the number of students who registered for the *Active Physics* course increased greatly (Carlone, 2003).

In the following years, Carlone observed two tendencies: First, the students perceived the course as "easy" physics, "fun" physics, even "blow-up" physics; second, the school community responded by pressuring for a more rigorous "real physics" course. Over a five-year span, the reform-based curriculum gradually reverted to its more traditional format. She concluded that the shaping of innovative science practice will always be influenced by contexts, and attempts to broaden the meaning of physics, and physics teaching, give rise to hidden complexities (Carlone, 2003).

In contrast with Carlone's findings and reflections, others have suggested that students' emphasis on the importance of "everyday life" aspects can be interpreted not only as "student interests" but also as an appeal to the social and cultural implications of physics. From this perspective, the teaching of physics should include, or perhaps center on, these social and cultural dimensions beyond the personal and purely scientific and mathematical. Teaching could, for instance, emphasize the role of pure physics in the associated sciences (environmental physics, biomedical physics, and so on). Other science fields have felt the same pull to the practical: Schwartz-Bloom (2003) argued that student performance in high school biology and chemistry classes will improve if interesting and relevant topics (such as pharmacology) are integrated. Ölme (2000) highlighted this same recommendation from the European Physical Society: Motivation for the study of physics emerges from the understanding that physics provides key knowledge for solving present and future problems in such areas as the environment, medicine and biology.

Specific contexts may also influence student perceptions. We consider here three studies that investigated student preferences and attitudes in (a) a low income area, (b) an alternative residential program, and (c) a predominantly African-American school.

Corbett and Wilson (2002) interviewed nearly 400 low-income, middle and high school adolescents in inner city schools in the USA undergoing district-wide educational reform. These students identified their teachers as the main factor determining how much they learn. Students characterized good teachers as the ones who (a) make sure students did their work; (b) controlled the classroom; (c) were willing to help students whenever and however the students wanted help; (d) explained assignments and content clearly; (e) varied the classroom routine; and (f) took the time to get to know students and their circumstances. It is interesting that students did not confuse teachers' personal qualities with their professional behavior. If the teacher had the six "good teacher" qualities identified, then demeanor, sense of humor, charisma, and other personal characteristics were unimportant. Furthermore, students equate good teaching with more learning. The students in this study based their evaluation of the reform efforts on the effects these reforms had on teacher behavior and the increase in the number of good teachers. Corbett and Wilson (2002) concluded that schools should guarantee that teachers act in ways that demonstrate how much they care about students and their learning.

A study in an alternative, tuition-free, residential high school in the United States reported student perceptions of learning needs and behavioral problems. The students involved came from diverse regions of the USA and previously had endured compound social problems: academic failure, substance abuse, expulsion, gang membership and so on. Easton (2002) describes how students identified specific areas of need--areas where deficiency is perceived as interfering with learning. Students referred to emotional needs, such as the need for self-esteem and personal accountability, and they talked about the need for teachers who care and use teaching methods that promote active and personalized learning. They further mentioned the need for high expectations on the part of the school (Easton, 2002).

Tucker, Herman, Pedersen, Vogel and Reinke (2000) analyzed student-generated recommendations for improving the academic success among African-American students. The responses suggest that parent and teacher encouragement, expectations and praise may improve student schoolwork and class participation; such improved preparation and participation may in turn enhance achievement. The authors also recognize the important role of peer interaction and how this can influence (for better or worse) academic behavior even prior to the onset of adolescence. The responses also showed, according to Tucker et al., that the students often lack self-management techniques and that these students could be empowered by the teaching of such techniques.

Students, then, recognize many different causes of failure in high school (and particularly in the sciences) and many different ways of improving achievement. Some common strategies can be identified in the international literature as to how to improve student success. It is important, however, to extend this body of data to other contexts and conditions. A better understanding of such student perceptions can provide educators, school managers and leaders another decision-making tool for defining and selecting policies for enhancing academic success and reducing the dropout rate. This study, therefore, sought to identify unprompted suggestions and recommendations provided by 10th-grade, science-tracked students in the south of Portugal both in terms of actions that should be taken by schools and by teachers.

METHOD

Participants

The participants in the study were 346 10th-grade, science-tracked students, from eight public schools in the Algarve region of southern Portugal. With a median age of 16, the sample included 214 girls (61.8%); 301 (87%) were Portuguese nationals. Two class groups from each school were selected. School curriculum for science-tracked students included five disciplines in the sciences: Physics-Chemistry, Biology-Geology, Mathematics, and two science laboratory techniques courses. While the sample is not probabilistic, relevant parameters are fairly typical of the Algarve. Slightly more than 11% of the sample had previously failed the 10th grade at least one time. Average evaluation of achievement (based on a 20-point scale where 10 is passing) was 12.5 in Physics-Chemistry, 11.5 in Mathematics, and 13.4 in Biology-Geology. About one quarter of the sample indicated they were currently failing Physics-Chemistry, about one third, Mathematics, and one tenth, Biology-Geology. Nearly all reported that they felt it was important to finish high school.

Material

A questionnaire was prepared based on the literature review. Four open response questions were posed asking for suggestions as to how to improve success in general and in the sciences. The questions solicited responses in terms of actions that should be taken both by schools and by teachers: (a) What can Physics-Chemistry teachers do to improve success in the discipline in 10th grade? (b) What can Mathematics teachers do to improve success in the discipline in 10th grade? (c) What can the School do to improve student success in 10th grade in general? (d) What can the School do to improve student success in Physics-Chemistry and Mathematics in the 10th grade?

Students were asked to give three suggestions for each of the questions.

Procedure

Prior to the field phase of the study, the data collection instrument and procedures were piloted in two other secondary schools in the same region. Data collectors (eight teachers, one in each school) presented the questionnaires to the students, asking for their collaboration, and remained in the room for the time necessary for students to complete the answers.

Questions of semantics will always be a challenge in this type of study. In order to tap the general, unprompted student responses, we could not specifically operationalize response terms (e.g. "creative") in the data collection phase. The meanings of such terms, as used in this study, flow from social interactions and the interpretation of those interactions. *Personal* meanings and understandings evolve but as Cobb and colleagues have pointed out, *normative* understandings also develop. Cobb has used the term "taken-as-shared" to refer to such meanings (e.g. Cobb, Wood, Yackel & McNeal, 1992). It is this kind of normative meaning that the coding procedure attempted to measure, without necessarily exposing specific operationalizations.

In order to identify a preliminary set of categories, the responses to each question were read, then re-read several times. Interpretations were adjusted in order to present the best account possible of student meanings. Although the students were asked to propose three suggestions for each question, some students gave only one or two, while others presented four suggestions. All the answers were coded. When in one suggestion the student repeats an idea, the answer was counted once only (for example, "be more patient in presenting the subject matter; cover the program at a slower pace"). Some of the answers were rather general and others were quite specific (for example, "math teachers should, while writing formulas on the blackboard, write one formula at a time, and discuss it and apply it, and only then should they write other formulas"). Some of the suggestions were complex, including several codable responses, and so were classified in more than one category. As an example we have this student response about mathematics teaching:

There are students who lack good background preparation, and so teachers have to understand that, and should explain in a more understandable manner and help students as much as necessary.

This response was coded in three response categories: "teachers are concerned", "explain better", and "help students".

Content analysis permitted the coding of suggestions regarding teacher actions into 12 variables (plus one additional category for other and uncodable responses). These were grouped into nine general constructs and analyzed both in terms of improving success in Physics/Chemistry as well as Mathematics. The answers to the two questions concerning recommendations to schools were organized into five constructs: (a) school organization and management; (b) teachers in school; (c) interactions in the classroom; (d) curriculum; and (e) equipment and other conditions.

RESULTS

Teachers

Physics-Chemistry. The first question asked what teachers can do to improve success in Physics-Chemistry in the 10th grade. Of the 346 students, 308 (89%) provided at least one response. A total of 714 suggestions were coded in the 12 substantive categories. One additional category included seldom-mentioned "other" responses. Some of these categories were then further reduced to form coherent practical suggestions.

Table 1 shows the frequencies and relative frequencies of each coded response. Categories derived from the data included the following student-generated suggestions:

1. Teachers should motivate students, and develop their self-confidence through creative teaching (112 responses). "Creative teaching" was frequently operationalized by students as the use of diverse and innovative methods involving greater student participation (93 responses). Thus 205 of 714 responses (28.7%) fell into this general suggestion category.
2. A second category appealed to the use of experimentation, practical exercises and a robust connection between classroom activities and real-world relevance (104 responses; 14.6%).
3. Teacher motivation was addressed in a third category (158 responses; 22.1%). Students suggested that teachers be more engaged in their teaching, that they should enjoy teaching and show the kind of concern for students learning that creates good classroom environment (97 responses). They further suggested that teachers be available for group and individual remediation (61 responses).
4. Teachers should prepare and present their classes with language appropriate for their students--it should be clear and understandable (62 responses; 8.7%). (The perception of "unclear language" in the classroom may be associated with the perception of a lack of adequate previous preparation. Students without adequate preparation would surely sense that the language used by teachers lacked clarity and understandability).
5. Teachers should have students resolve more application exercises (34 responses) and worksheets (16 responses). This category, with 50 responses (7%), could conceivably be combined with category 2, above. We chose to maintain it as a separate student suggestion due to its emphasis on classroom exercises and *formative evaluation* as opposed to actual *teaching* that is emphasized in category 2.
6. Students also suggested that teachers should use diverse forms of assessment and not limit evaluation to the use of highly demanding tests (39 answers; 5.5%).
7. In this category, 29 responses (4.1%) focused on questions of curriculum, saying that the official program of the Physics-Chemistry discipline (defined by the Ministry of Education) should be reduced, and more time should be allowed for the learning of concepts.

Improvement of school conditions was mentioned in 13 responses (1.8%) and 19 responses (2.7%) indicated that Physics-Chemistry teachers "do their best" and therefore the responding students provided no further suggestions for improvement. Still a few responses (f=6; 0.8%) mentioned that teachers should verify student preparation when they enter 10th grade and do revisions of 9th grade topics before advancing to new material.

Mathematics. The same question was asked regarding Mathematics teachers. Table 1 shows the suggestions provided by 300 (86.7%) of the students who offered 669 responses. The suggestion categories used were the same as those used for Physics-Chemistry and, in general, the proportion of responses was similar for both disciplines. The proportion of total responses was higher for Mathematics teachers in categories (a)

Table 1. What can Teachers do to Improve Success in Physics-Chemistry and Mathematics?

		Physics/ Chemistry		Math	
		f	%	f	%
	a. Teachers should motivate students, develop their self-esteem, self-confidence and self-purpose, by teaching in a more interesting and creative manner	112	15.7	123	18.4
1	b. Teachers should use diverse, innovative methods involving greater student participation, in ways that make difficult subject matter more understandable	93	13.0	96	14.3
2	c. Teachers should have classes in which students perform experiments and other practical activities; practical, real-life, activities	104	14.6	35	5.2
	d. Teachers should be highly engaged in their teaching, empathic, patient, just and fair, should enjoy teaching and be concerned with student comprehension of subject-matter, and with creating a good class environment	97	13.6	82	12.3
3	e. Teachers should help students individually, in remediation classes or extra-class time, above all the students with more difficulties	61	8.5	79	11.8
4	f. Teachers should explain in understandable and clear language	62	8.7	65	9.7
5	g. Teachers should have students resolve more application exercises	34	4.8	44	6.6
	h. Teachers should provide more worksheets	16	2.2	16	2.4
6	i. Teachers should use diverse forms of evaluation and not limit evaluation to the use of highly demanding tests	39	5.5	43	6.4
7	j. Curriculum issues: the official program should be shorter and allow more time for learning concepts	29	4.1	32	4.8
8	k. School conditions should be improved	13	1.8	12	1.8
9	l. Teachers do their best (no suggestions for improvement)	19	2.7	11	1.6
	m. Other answers (8 different categories)	35	4.9	31	4.6
	Total Responses	714	100.0	669	100.0

"Teachers should motivate students, develop their self-esteem, self-confidence and self-purpose, by teaching in a more interesting and creative manner" (18.4 % versus 15.7 %); (b) "use diverse, innovative methods involving greater student participation, in ways that make difficult subject matter more understandable" (14.3 % versus 13.0 %); (e) "help students individually, in remediation classes or extra-class time, above all the students with more difficulties" (11.8 % versus 8.5 %); and (f) "Teachers should explain in understandable and clear language" (9.7 % versus 8.7 %).

The relative frequency of responses was also higher for Mathematics in categories involving types of evaluation (6.4 % versus 5.5 %) and the use of application exercises/worksheets (9.0 % versus 7.0 %).

School

Academic Success in General. To the question about what schools can do improve academic success in general, 325 students (93.9 %) provided at least one suggestion and 811 responses were coded. The recommendations about possible school actions were organized into five categories: (a) School Organization and Management; (b) Teachers in School, (c) Classroom Interactions; (d) Curriculum; and (e) Equipment and other Conditions. Table 2 shows the frequencies and relative frequencies within these coding categories.

Of a total of 811 responses to the question regarding academic success in general, 357 (44.0%) were coded in the category of School Organization and Management. The largest proportion of these responses dealt with early identification of student learning problems and the furnishing of institutional remedial support such as tutoring (90 of 357 responses; 25.2%). A second group of responses focused on institutional promotion of future student objectives and good study methods (61 answers). The organization of extracurricular activities (clubs, contests, debates, visits, fairs, real-life projects) was mentioned in 57 suggestions. Concerns about scheduling issues (for example, reducing the number of in-class hours) appeared 49 times. Less frequently

Table2. What Can the School do to Improve Academic Success?

	Category	Success in Sciences and Math?		Success in General	
		f	%	*f*	%
1	School Organization and Management	207	29.3	357	44.0
2	Teachers in School	220	31.1	179	22.1
3	Classroom interaction	94	13.3	72	8.9
4	Curriculum	96	13.6	74	9.1
5	Equipment and other Conditions	90	12.7	129	15.9
	Totals	**707**	**100.0**	**811**	**100.0**

mentioned responses included: Schools should better train and evaluate teachers; they should listen to students concerns, recognize student achievement (though prizes, honor roll, merit scholarships); they should invest in career education. Eight responses indicated that the school already does the best it can.

Student responses revealed numerous recommendations related to teachers (179 of 811; 22.1%). These suggestions were often associated with the school's presumed power to hire, supervise and direct teachers, for instance: (a) contract qualified and competent teachers (48 responses); (b) hire teachers that show concern for students and that provide them with motivation and support (43 responses); (c) ensure that teachers use diverse, interactive teaching, with practical activities based on student needs (31 responses); (d) have teachers that are committed to teaching, enjoy teaching and are empathic and patient (28 answers).

A total of 72 recommendations were coded concerning classroom interactions: (a) 29 suggestions mentioned that the school should support practical activities, and dynamic, non-lecture classes; (b) 20 mentioned specifically that classes should be "fun"; (c) 20 mentioned a need for better class environment and better communication (both teacher-student and student-student communication).

Recommendations regarding Curriculum were voiced 74 times and included such comments as: (a) Eliminate from the official program everything that is irrelevant, out-of-date, uninteresting or difficult; the official programs should be shorter, the current program attempts to cover too much in the time available ($f = 28$); (b) tests should be easier, other forms of evaluation should be used and evaluation should be consistent with what is being taught ($f = 21$); (c) difficulty of the 10th grade should be decreased ($f = 20$). While some of the recommendations in this category include a hedonic component (the appeal for less challenging material and easier evaluation), we chose to leave them as the students reported them.

Insufficient school conditions and equipment were noted in 129 of the 811 suggestions about what schools can do to improve academic success in general. Within this category, we noted the following often mentioned recommendations: (a) school should have better installations (including tutoring rooms, labs, quiet study rooms, libraries); better equipment (Information and Communication Technology); and better conditions (environmental heating and cooling) (75 responses); (b) more and better didactical material (computer hardware and software; laboratory material) (41 responses); and (c) smaller classes (13 responses).

Success in Physics-Chemistry and Mathematics. The 707 responses to the question, "What can the school do to improve the success of students in Physics-Chemistry and Mathematics in the 10th grade?" were organized into the same five categories as for improving success in general. Although the categories are the same, the emphasis in each category, based on proportion of responses, is somewhat different for success in the 10th grade in general and for success in Physics-Chemistry and Mathematics. Table 2 shows the results, based on the responses of 314 students (90.7%) who provided at least one suggestion.

The proportion of responses regarding success in Physics-Chemistry and Mathematics was greater than that of success in general in three categories: Teachers in School (31.1% versus 22.1% for success in general); Classroom Interaction (13.3% versus 8.9%); and Curriculum (13.6% versus 9.1%). Success in science and mathematics was associated principally with responses related to the action of teachers; success in general was associated more with school organization and management.

The 207 responses classified as School Organization and Management (29.3% of 707) included: (a) provide tutoring support including the early identification of student needs (f=70); (b) motivate students to study sciences/develop in students good study methods (43 answers); (c) organize extra-curricula pedagogical activities (clubs, contests, debates, visits, fairs, real-life projects--39 answers). Other responses focused on teacher selection, hiring, evaluation and development (19 answers).

Slightly less than one third of the responses (*f* = 220) referred to how the school should influence teacher actions. In this category, two sub-categories appeared that were not mentioned in relation to success in general: (a) require teachers to assign more exercises and homework and to teach extra classes; and (b) require teachers to show the applications and importance of subject material and make learning fun.

The 94 recommendations (13.3%) classified as Classroom Interaction included the frequent suggestion that schools should encourage practice-oriented classroom interaction, specifically more experimental work. The frequency of suggestions regarding better classroom communication was inferior to that regarding success in general.

Responses in the category of Curriculum (*f*= 96; 13.6%) emphasized the need to eliminate from the official curriculum irrelevant, out-of-date material. Some students proposed reducing subject-matter difficulty; some indicated that other forms of evaluation, consistent with what is taught, should be used.

The responses that emphasized the importance of Equipment and Other Conditions (*f*= 90; 12.7%) included (a) more and better didactical material, namely computer and lab material; (b) better installations (classrooms to be used as tutoring rooms, labs, quiet spaces for studying).

DISCUSSION

Suggestions from students emphasize the importance of both teacher actions and school policies on reducing levels of academic failure in 10th grade secondary schools in Portugal. Without attempting to suggest any hierarchy, we can summarize some of the unprompted, student-generated recommendations. First, with regard to teachers and teaching, three areas emerge: (a) strategies, (b) affect and (c) curriculum.

Teaching strategies recommended by students focused on how teachers can motivate students through the use of diverse methods, varying the routine of classroom activities. They also recommended that teachers permit students a greater input in defining and implementing practical, experimental, real-life activities, and that there be more application exercises including homework and in-class exercises. They further urged teachers to provide remedial assistance to those students who require it.

In the affective domain, students indicated that greater achievement could be attained by teachers who enjoy teaching, who are patient and fair, and concerned with student understanding of subject matter. In short, they recommend that teachers zealously create a positive classroom environment. The students indicate their belief that this will help develop self-esteem and self-confidence as well as assist the construction of long-term life goals. In this, our results are most in accord with those of Easton (2002). Unlike Easton's results, the unprompted student responses in the current study did not mention a need for high teacher expectations. While this factor may not receive emphasis on the part of the students, previous evidence from Portuguese high school students suggests a positive correlation between perceived expectations and achievement (Fonseca & Conboy, 2006).

Students may not comprehend the policies and politics surrounding curriculum issues, but some do recognize the difficulty of covering all the material in the official program in the time allotted. Though they may appreciate that the teacher's prerogative is limited in this area, they nonetheless recommend that the program should be shorter and allow more time for the learning of complex concepts.

The general pattern of responses was similar whether the students were referring to Physics/Chemistry or to Mathematics. This could be a function of the question format, an artifact of the qualitative coding process or it could reflect that student concerns are indeed generally similar across disciplines. In some cases, predictable differences were observed between areas. When students recommend greater emphasis on experiments in Physics/Chemistry compared to Mathematics (where instead they refer to practical activities), the responses lend some credence to the validity of area-specific concerns within general categories. However we cannot rule out the possibility that response categories may be an artifact of question formats or encoding procedures.

With regard to student-generated recommendations aimed at schools, five general areas emerged: (a) school organization and management; (b) teachers in school; (c) interactions in the classroom; (d) curriculum; and (e) equipment and other conditions. (It is interesting to note that the middle three--teachers, interactions and curriculum-- recapitulate the recommendations aimed at teachers. Students appear to know what they want done, but do not necessarily appreciate administrative mechanisms and hierarchies). Within these categories, different patterns of response surfaced when the students referred to academic success in general and when they referred to success in science and mathematics. School organization and management received the highest proportion (nearly half) of suggestions from students regarding how to improve academic success in general, followed by the importance of teachers. In science and mathematics these two categories of recommendations each comprise about the 30% of the coded responses. The relative equality of these two constructs (based on proportion of responses) may be explained by student perceptions of the school's role in hiring and supervising teachers, a perception that, in the Portuguese system, is mistaken. At present, these processes are largely centralized and a school's power to reward good teaching practice, and remedy or remove teachers for poor practice is strictly limited.

Of the six student-identified characteristics of good teaching/factors of success identified by Corbett and Wilson (2002), four were also reported in our study. Students suggested that teachers should vary the classroom routine, be willing to provide remedial assistance, explain assignments and content clearly, and take the time to get to know students and their circumstances. Controlling the classroom was mentioned by a very small number of students (five with respect to math teachers and three with respect to physics/chemistry teachers).

The results are also generally consistent with those of Angell et al. (2004), though the terms used may vary. When Angell et al. refer to a student preference for more "pupil-centered" and "qualitative" teaching methods, perhaps their meaning is similar to what we have called "varying the classroom routine" and using real-life content (as opposed to mathematical presentation of concepts). This expanded repertoire of teaching strategies is also supported by Seidel and Prenzel (2002). Our data also agree with regards to greater use of experimentation, practical exercises, project work and more student participation. Students in our study did not, however, make reference to the use of additional literature besides the textbook as in Angell et al. (2004), nor did the Norwegian students voice affective concerns that emerged in our data about teachers being "engaged", "concerned with student learning", and "creating a good classroom environment". Norwegian students also seem less preoccupied with remediation and extra tutoring classes.

The student-generated suggestions and recommendations we observed are, moreover, in general agreement with those of educational leaders who advise systemic reform (AAAS, 1990; Anderson, et al., 2003; Fonseca, 2003; NRC, 1996; Supovitz & Taylor, 2005). Students did not, however, report any recommendations regarding school-community relations or school-parent relations; nor did they relate suggestions pertaining to science enterprise and research, generally emphasized as important factors by experts. This is not surprising for two reasons: first because questions of enterprise are beyond most students' experience and secondly, since these factors are often disregarded even by many responsible educators when re-conceptualizing, and restructuring science and mathematics practice.

In the current study, using a method of unprompted, open-response questions, the students' prior academic preparation was not mentioned among recommendations for reducing failure. This factor was, however, salient among "failure factors" reported by Portuguese secondary-school students to Fonseca and Conboy (2006). That research, however, used a literature-based, predefined list of factors for the students to rate. Perhaps students interpreted the questions in the current study as having a personal, future orientation ("What can be done in the *future* to improve *your own* success…?") as opposed to a general reform orientation ("What can be done *now* to avoid a continuation of past problems experienced by *many* students?"). Both the differences in response owing to item presentation (open- or closed-format) as well as the possible interpretations (including scope of response and temporal interpretations) should be addressed in future research in order to clarify possible ambiguities.

The sample in this study, though non-probabalistic, was a fairly representative group of grade 10, science-tracked students in southern Portugal. As such the data are a useful contribution to the international literature on student perceptions; we feel they describe the Portuguese reality. They should not, however, be generalized beyond this population owing to specific cultural and organizational contexts.

One area of methodological concern may be the question of the consequences of using the *response* as the unit of analysis as opposed to the *student*. The choice of this method means that the number of units analyzed (codable responses) is greater than the number of units actually included in the study (students). It creates a response bias in which students who provide more responses have greater impact on the results than those who provide fewer responses. These questions are primarily of concern in statistical and inferential studies where an inflated value of N could increase the probability of encountering statistical significance. However, their importance in a descriptive study such as this is quite limited. Since no response was coded twice in the same category (i.e. repetitions of the same idea by a given student were tallied only once), we are confident that the student responses are fairly representative of unprompted student concerns.

The suggestion of Angell et al. (2004) that it can be difficult for students to imagine alternatives to the teaching they receive garners little support from our data. This may involve cultural differences between the Norwegian and Portuguese populations studied, or it may reflect organizational differences between the two systems. In our sample, very few students responded saying that schools, or teachers, "do their best"; most students had no difficulty in voicing critiques and recommendations. The number of students providing at least one codable response to each question was always superior to 85%. The proportion of responding students was lowest when these were asked to make recommendations to teachers regarding how to improve success in mathematics. This lower proportion of suggestions may indeed reflect a perception of instruction methods in mathematics as more determined by the nature of the subject matter. Since there is little basis for comparison of methods in mathematics with other areas, students may have greater difficulty in imagining alternative methods.

The literature suggests a cultural mechanism by which these two student populations differentially perceive causes of academic success and failure. The Norwegian students acknowledged their responsibility in learning, asserting that success depended largely on their own enthusiasm and engagement (Angell et al., 2004). But Fonseca and Conboy (2006) found that Portuguese students attributed failure to factors that were essentially external to them and uncontrollable, such as teaching quality. The present study did not shed light on this important question. It is a question of some significance: if cultural differences emerge in patterns of how students attribute causes for failure, this could suggest specific avenues of intervention for different societies. In Portugal, it might inform teacher education in encouraging failure attributions to internal and controllable factors (e.g. the student should increase personal effort, and improve efficiency of study habits). Future studies of this type should therefore consider including questions of the nature, "What can the students themselves do to improve success in mathematics and physics/chemistry?" Unprompted, student-generated responses to this kind of question could help us understand if students consider their own actions as important, or if they consider themselves as pawns in an education game.

While the students did appeal for stronger connections between class content and "everyday, real-life events", the results fail to shed light on the question of just what it means to incorporate "everyday, real-life events" in the teaching of science and mathematics. Future studies should attempt to better operationalize this colloquial term, determine its social representations (from both teacher and student perspectives) and verify consequences of implementing competing definitions for teaching practice. As a first attempt at operationalizing the dichotomy suggested by the work of Carlone (2003) and by Schwartz-Bloom (2003), we suggest that there is pedagogical value in incorporating *learning-relevant* real-life events in teaching practice while there is motivational value in incorporating *goal-relevant* real-life information in teaching practice. In the first case, students can be encouraged to make connections between the new content being learned and prior knowledge from personal experience. In the second case, teachers can motivate learners by linking new content to real-world problems that may be beyond personal experience, but are within the realm of interests, aspirations and future professions.

We hesitate to adopt the students' recommendation of making science and mathematics courses easier, with simplistic evaluation. Many theories and empirical results point to the importance of challenging, but attainable, goals in maximizing student motivation. On the other hand, the not infrequent student recommendation to shorten the program and allow more time to consolidate knowledge and understanding should not be dismissed as merely a self-serving, hedonic appeal by students. Casual observation demonstrates that many science and mathematics teachers in Portugal would agree with the students' assessment of the excessive nature of the programs. Such concerns can only be addressed at the national, ministerial, level, but the data to evaluate the appropriateness, or excessive nature of the programs, must originate at the grass-roots school level (including input from students, teachers and parents).

While the implementation of student suggestions may not be appropriate in all cases, their study can be useful in identifying problem areas, and in some instances may offer sound advice to teachers and educational leaders.

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