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SECONDARY STUDENT PERCEPTIONS OF FACTORS EFFECTING FAILURE IN SCIENCE IN PORTUGAL

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ABSTRACT. High rates of failure in secondary level science classes are a problem worldwide. Effective teaching and efficient management of schools requires information as to the causes of failure. One approach to acquiring this information is to improve our understanding of what the students themselves perceive as the causes and antecedents of school failure. In this article, we analyze the perceptions of the factors of academic failure among grade-ten, science-tracked students. Students from eight schools in southern Portugal (N=346) participated in the study. The major factors of failure in 10th grade science courses, according to students, are quality of teaching and previous student preparation. One third of the students did not think that secondary science education prepared them for life in a scientific-technological society. A culture of high expectancy on the part of teachers, parents and administrators may be key to influencing rates of success.

KEYWORDS. Failure, Management Practices, Secondary Science, Student Perceptions, Teaching.

INTRODUCTION

Failure rates are high and deficient learning in science is commonplace at both the middle and the secondary school levels in Portugal (Fonseca, 2003; GAVE, 2000, 2001; OECD, 2004). Among the 40 countries involved in the 2000 and 2003 PISA studies, Portuguese students rank among the lowest in science performance (GAVE, 2001; OECD, 2004). These shortcomings in science achievement are evident in spite of successive reforms in science education-a frequent phenomenon consistent with what has been observed in other international studies (Davies, 2003; Kozoll & Osborne, 2004; National Center for Educational Statistics, 2003).

The poor results in science achievement reflect a general panorama of poor academic performance. Portugal has the highest school abandonment rate among 26 countries studied by the European Union (European Commission, 2000). In 2001, among those 18 to 24 years of age, 45% had abandoned school without completing the 12th grade. In the same age range, one fourth had abandoned school without completing the 9th grade (Ministério da Educação, 2002). By 2003, about one third of the students in the 6th through 9th grades had experienced some form

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of school failure. The percentage is even higher in the secondary grades. As a result, only 20% of the active population in Portugal had a high school diploma in 2005 ("Insucesso escolar," 2004; Dâmaso, 2005). In southern Portugal, science performance of 15-year-olds is among the lowest in the country (GAVE, 2001) and the failure rate for all secondary students in the region is most prominent at the tenth grade level (Carreira & André, 2000).

The Portuguese educational system includes area-specific tracking after the ninth grade. Upon entering tenth grade, students must choose which major subject area they will pursue—for instance sciences, humanities, social sciences, or technology. Students who select the science track are required to enroll in eight disciplines, five of which are in the sciences: Physics/Chemistry, Biology/Geology, Mathematics, and two disciplines in Laboratory Techniques (in Physics/Chemistry and Biology/Geology). However, even among the science-tracked students in the 10th, 11th and 12th grades, failure rates continue to be high, particularly in Physics/Chemistry and Mathematics.

Because of the high levels of school abandonment, the students who enter tenth grade are already a select group. Within this select group, the students who choose the science track represent an elite in terms of academic performance and motivation. Even so, many do not enjoy success in secondary education, particularly in the 10th grade. This leads to a series of important questions for science educators and other educational leaders and policy makers: We ask first, why should this be the case? What are the factors students identify for the high failure rate? Are there relations between the factors identified by the students and other variables? And what implications for teaching, curriculum, and school organization can we infer?

The literature provides some possible answers to these questions. A number of psychosocial, organizational, teacher and student variables seem important in influencing success or failure: Parenting practices and parental involvement with the school explain much of the variation in school performance according to Desimone (1999). Student perceptions of meaningfulness, challenge, choice and appeal of class activities have been associated with motivation and learning (Raineri & Gerber, 2004; Gentry & Springer, 2002). And the science teacher has been found to be the most important factor in improving student achievement in schools (Ballone-Duran, Czerniak & Haney, 2005).

Anthony (2000) reported a study of perceptions of factors influencing success in mathematics and emphasized the role of motivation. Students and lecturers agreed on the importance of motivation, however their opinions diverged in relation to factors such as importance of active learning, help-seeking and student effort. Lecturers emphasized controllable student characteristics, while students were more prone to blame failure on course design and teaching quality.

Easton (2002) interviewed students from an alternative residential high school in the USA in order to determine perceptions of learning needs. Students identified the need for self-

esteem, personal accountability, and personalized learning. They talked about the need for teachers who care and also about active learning. They further mentioned the need to feel emotionally safe, the need for high expectancy on the part of the school and the need for self-directed learning/learning by choice.

In analyzing student-generated solutions to enhance the academic success of African-American youth, Tucker, Herman, Pedersen, Vogel and Reinke (2000) found that both academic preparation of students and positive peer influences would enhance academic success and that praise and encouragement by teachers and parents is needed to facilitate student school work and achievement. They further affirm that student achievement seems to be associated with occupational aspirations. Similarly, Wong, Wiest and Cusick (2002) state that student perceptions of teacher behaviors that promote the development of student autonomy, parent involvement, competence and self-worth were predictors of motivation and achievement. Factors such as age and gender may also be related to attitudes concerning factors of achievement. So concluded Whitelaw, Milosevic and Daniels (2000) while cautioning that the relations are complex and require further study.

In Portugal, studies conducted in schools that had confronted and reduced failure rates highlight the importance of variables such as (a) school organization, including a collaborative environment with parental involvement; (b) relevant curriculum and classroom activities; and (c) the quality of science teaching, including teacher support and expectancies (Fonseca, 2003).

While many strategies may be put forward to reduce high failure rates, at a primary level it is important for science educators and other educational leaders and policy makers to recognize what the students themselves perceive as the causes and antecedents of school failure in order to better comprehend students' academic needs. A better understanding of student perceptions of the factors that lead to failure can provide one way of informing the science education community about what should be done if we want to increase academic success and reduce the risk of school abandonment. The purpose of this study, therefore, was to analyze student perceptions of the factors involved in academic failure in science disciplines (including Physics/Chemistry, Biology/Geology and Mathematics). The tenth grade was chosen due to its high incidence of failure.

METHOD

Participants

The study included 346 tenth-grade, science-tracked students, from eight state sponsored schools in the Algarve region of southern Portugal. In each school, two class groups were selected to participate.

Materials

Based on the relevant literature, a data collection instrument was developed that included variables related to achievement, teacher expectancies, support mechanisms and parent involvement. The questionnaire also asked about student views on the importance of school (for instance, if the students felt that secondary school prepared them for life); if they felt it was important to finish grade 12 and why; and if science disciplines are useful for their future. Three summative scales included in the questionnaire (parent involvement--six items; importance of the sciences for the future--seven items; and student aspirations--six items) displayed moderate reliability (α = .734, .775 and .742, respectively).

Six variables (school organization, school physical conditions, quality of teaching, previous student preparation, outside interests and the difficulty of the subject matter) were proposed to students as possible failure factors in the 10th grade. Each was presented as a possible cause of (a) failure in general, (b) failure in mathematics and (c) failure in science.

These individual items were combined in summative scales measuring the tendency to attribute failure to the six specific causes. Each scale was composed of three items measuring the combined attributional tendency for failure in science, mathematics and academic failure in general. We observed good reliabilities for these scales (school organization, α = .90; previous preparation, α =. 80; physical conditions of the school, α = .83; teaching quality, α = .80; outside interests, α = .91; difficulty of the material, α = .80).

Procedure

Student participants completed the responded to the data collection instrument individually,Data were collected in group settings at the end of the school year. 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.

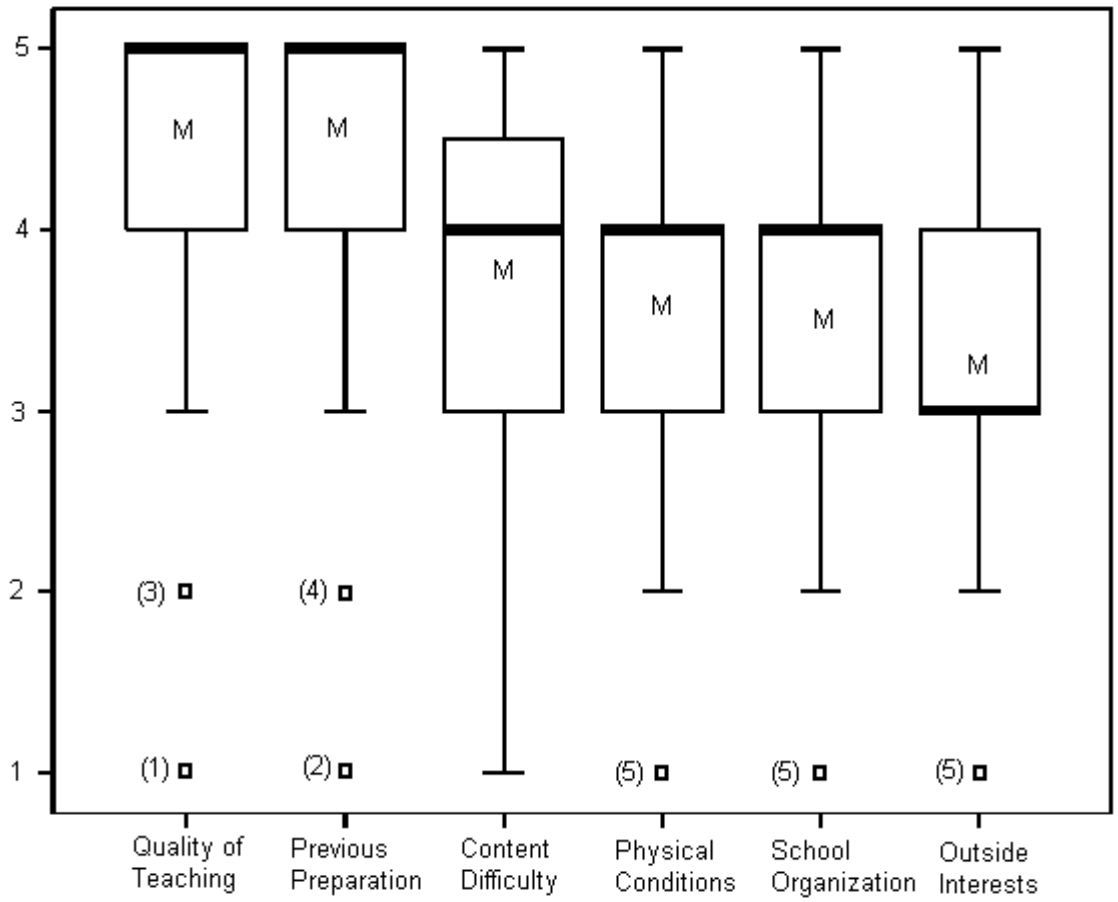
RESULTS

Sample characteristics

The study included 214 girls and 132 boys with a median age of 16. Of the students, 13% reported nationalities other than Portuguese (in the Algarve state school system there are students from many different countries, particularly Eastern Europe and Africa). Of all the students, 11.3% had previously failed the tenth grade at least once. Mean tenth-grade science and mathematics classifications for the sample were typical for the Algarve. On a scale that varies from 0 to 20, with 10 representing a passing grade, mean scores were 12.5 in Physics and Chemistry (PC), 11.5 in Mathematics (Math), and 13.4 in Biology and Geology (BG). About

25% of students reported failing grades in PC; about 34% in Math and 9% in BG. The great majority of students lived with at least one parent (331, of whom 255 lived with both parents). Almost all of the students (98%) affirmed that it was important to finish secondary school. When asked why it was important to finish high school, 90% of these indicated, "in order to continue studies" and 92% specified, "to get a good job".

Figure 1: Boxplots for six student-rated failure factors



Note: Each Boxplot shows the Median (heavy horizontal line), Interquartile range, Mean (M), theoretical minimum and maximum scores as well as the number of outliers.

Failure factors

Students were asked to rate the importance, as causes of academic failure in science, of six factors identified in the literature. Each factor was rated on a five-point scale, anchored at the extremes as Very Important (5) and Not at all Important (1). Figure 1 shows expanded box-plots of the central tendency and dispersion of the responses. The Quality of Science Teaching (M= 4.55; *sd* = .68) and Previous Student Preparation (*M*= 4.53; *sd* = .71) were rated the most important causes of failure followed by Difficulty of Academic Content (*M*= 3.83; *sd* = .97),

Physical Conditions of the School (*M*= 3.62; *sd* = .97), School Organization (*M*= 3.56; *sd* = .95), and conflicting Outside Interests (*M*= 3.31; *sd* = 1.07).

Table 1: Pearson Correlations among Principal Variables

		1	2	3	4	5	6
1. Parent Involvement	*r*	--					
	N	346					
2. Teacher expectancy	*r*	**.204****	--				
	N	321	321				
3. Perceived Support	*r*	**.165****	.103	--			
	N	342	319	342			
4. Science Achievement	*r*	**.150***	**.239****	.023	--		
	N	287	267	285	287		
5. Attribution to Difficulty	*r*	-.029	-.053	-.007	**-.265****	--	
	N	340	315	336	282	340	
6. Science Related Vocation	*r*	**.195****	.114	.093	**.170****	-.055	--
	N	308	287	306	262	303	308

* *p* (2-tailed) < .05.
** *p* (2-tailed) < .01.

Intercorrelations of the Principal Variables

Table 1 presents Pearson correlations among the principal variables in the study.

Parent involvement and teacher expectancies. Small but significant correlations support the following conclusions: Students reporting higher parental involvement also may tend to believe (a) that their teachers expect them to work hard and learn a great deal (r= .204; $p<.01$); and (b) that support mechanisms exist in school (r= .165; $p<.01$). Higher parental involvement and teacher expectancies were also associated with higher grades in science (r= .150; $p<.05$ and r=.239; $p<.01$, respectively).

Science achievement. In addition to the associations with parent involvement and teacher expectancies, science grades were negatively correlated with the tendency to attribute failure to the difficultly of the academic material (r = -.265; $p<.01$). A small but significant association was observed between grades and a vocational goal that was science related (r = .170; $p<.01$). Science achievement was also positively correlated with the perceived future importance of science disciplines to the students' lives (physics-chemistry, r = .327; biology-geology, r = .188; mathematics, r = .155; all $p<.01$).

The participants in the study also indicated reasons for completing secondary education. Science achievement was positively associated with the choice "because I like to learn" (r = .216; $p<.01$) and negatively associated with the choices "to please parents" (r = -.251; $p<.01$) and "so I don't have to get a job" (r = -.174; $p<.01$).

Table 2 shows the results of a multiple regression analysis of three simultaneously entered factors predicting science achievement. Perception of Teacher Expectancy, Failure Attributions to Difficulty of Material and Science Related Vocation were included as predictors, first because of their observed correlations with science achievement, and second since these factors are uncorrelated among themselves. Simultaneous entry of the factors was employed rather than stepwise entry, first since there are no theoretical constraints on the exploratory model, and second in order to avoid the problem of uncontrolled error rates (Onwuegbuzie & Daniel, 2003). The case/independent variable ratio in the analysis exceeded the requirements suggested by Green (1991). Analysis of residual plots verified the linearity of the relation. This three-factor model explained about 16% of the variance in science achievement.

Table 2: Summary of Simultaneous Regression for Variables Predicting Science Achievement

Variable	***B***	***SEB***	β	***t***	***p<***
Perceived Teacher Expectancy	1.52	.432	.213	5.53	.010
Difficulty Attribution	-.349	.076	-.273	-4.57	.001
Science Related Vocation	1.15	.488	.142	2.35	.030

Note. $R^2 = .16$

Analysis by gender

There were no differences in science achievement on the basis of gender. As verified in a series of Mann-Whitney tests, the girls in the study tended to attribute more importance than the boys to the failure factor Quality of Teaching in tenth grade in general, and also specifically in Mathematics and Physics/Chemistry (all tests $p<.05$). Girls also rated Previous Preparation for the tenth grade in general, and specifically for failure in Physics/Chemistry, as more important as a failure factor than did the boys in the study (both tests $p<.01$).

Additional analyses of contingency tables revealed other small but significant relations. We report here measures of effect size using coefficient ϕ. Girls were more likely than boys to choose the option "to pursue further studies" as a reason to finish grade 12 ($\phi = .13$; $p=.014$). The option "because I like to learn" was more frequently indicated by girls than by boys as a reason to finish grade 12 ($\phi = .13$; $p=.016$). Girls had a tendency to affirm, more frequently than boys, the existence of support mechanisms ("Is there someone in school you can ask for help if you need it?") ($\phi = .13$; $p=.014$).

Secondary Science as Life Preparation

When asked if secondary education prepares students to function effectively in today's scientific-technological society, fully one third of the participants (35.1%) said "no". Students

who thought that secondary science was good preparation also tended to believe that academic support mechanisms exist in the school (ϕ =.185; p=.001). No relation was observed between the perceived preparation that secondary science provides for life and "parent involvement", nor with achievement as measured by science grades.

DISCUSSION

Effective science education implies the creation of environments for maximizing learning success, which in turn requires information as to the causes of failure. The findings and conclusion of this study provide some useful insights for science educators and other educational leaders regarding the teaching and learning of secondary level science.

The students in this study perceive the lack of quality teaching and a lack of previous student preparation as the major failure factors in the tenth grade. About one-third of the students (regardless of their level of academic success) do not believe that secondary school prepares them for our scientific-technological society. The findings in this study replicate results of previous studies that show an association between achievement and student perceptions of teacher expectancies, parent involvement, quality of science teaching, a supportive learning environment, and previous preparation. It extends those findings to science learning in southwest Europe.

Some results of this study can be interpreted in terms of motivation and attribution theory: As Covington (2000) found, although the academic and social goals that students bring to class are important as a factor for achievement, another factor is equally important-- the motivating properties of these goals. An individual student can have goals, can express those goals and even justify the goals without constructively acting upon them. This helps explain the case of those students who want to achieve good grades (the goal) but do not really work for them (lack of motivating property of the goal). The emotional and motivational component of goals interacts with the cognitive components to influence learning and the will to continue learning. This may explain in part why failure is so frequent among science-tracked students in Portugal, a group that should be an academic elite.

The data reveal that student affects and emotions provide motivational impulse to the goal of achievement. For instance, the importance attributed to individual science disciplines for a student's future, and enjoying learning as a reason for wanting to finish high school were both associated with greater achievement. On the other hand, perceiving subject matter as difficult, choosing "To please parents" and "To not have to get a job" as reasons to finish high school, were both associated with lower achievement, which can be inferred as lack of motivation in spite of the existence of the academic goal (to finish high school).

Our data collection instrument was based on a review of relevant literature. It is

interesting to note, however, that all the failure factors so identified could be considered, within the scope of attribution theory (Weiner, 1980, 1986), as external, stable and uncontrollable. For instance, there is little basis for a student to believe that her/his own actions might influence school organization, physical conditions, the quality of teaching, difficulty of material or previous preparation. If these are indeed the predominant attributions for failure, as the literature suggests, students have no cognitive basis for altering their own behavior in an attempt to improve achievement outcomes. By encouraging attributions to internal, unstable and controllable factors, such as effort, teachers and parents can sow the cognitive seeds for behavioral change leading to greater academic success.

The associations encountered in this study are suggestive, but are not strong individually. They paint a picture of a multifaceted system that reflects the complexity of the problem of academic success or failure in secondary schools. These results are in general conformity with previous studies (Buxton, 2005, 2003; Yore, Anderson, & Shymansky, 2005): There is no single factor identified through which educational professionals can expect to effect change. To the contrary, a constellation of factors must be addressed in any program designed to create environments for maximizing learning success.

Despite the general agreement of our data with previous studies, our results differ from the position of Whitelaw et al. (2000) in that no achievement differences were found between the young men and women in the study. A number of attitudinal differences were observed however, with the girls tending, in general, to display a more positive outlook than the boys in the study. We also differ from authors (e. g. Desimone, 1999) who affirm that a large portion of the variance in science achievement can be explained by a linear relation with parental involvement.

Our data suggest that, in the Portuguese context, and with science-tracked secondary students, the association between parental involvement and achievement, though real, is small: Perhaps 3% of the variance in achievement can be so explained. Due to its correlation with Teacher Expectancy, Parental Involvement was not included in the three-factor regression model presented. Once Teacher Expectancy is included, Parental Involvement fails to enhance the predictive value of the model. These discrepancies in our results may have their origin in cultural differences of the populations studied. However, a more parsimonious explanation may be based on a statistical artifact. Only a reduced number of students experience the success necessary to complete the ninth grade. Fewer still are sufficiently motivated to attempt the challenging science track in secondary school. Therefore, the group studied may be considered a fairly homogeneous elite. The small correlation observed between parent involvement and achievement may simply be due to reduced variability in parental involvement. That is, in this restricted group, the parents may all be substantially involved in their children's learning, attenuating correlations observed between this variable and others. Further research in Portugal, with more heterogeneous student groups, will help resolve the question.

The results of this study, as well as previous research, indicate some of the elements to be considered in attempts to understand and exploit, pedagogically, student perceptions of failure: (a) teacher expectancies, (b) a supportive learning environment, (c) parent involvement, (d) previous academic preparation, and (e) quality of science teaching.

Science educators and school leaders need to implement measures that encourage the development of teacher expectancies for high academic performance. The ultimate goal should be the development of a culture of high expectancies within a supportive environment. While it may seem contradictory, this implies both the availability of generous support mechanisms and, at the same time, a low tolerance for failure. Too often, the existence of support mechanisms, especially in the presence of students deemed "at risk", is tied to a *laissez faire* attitude of the passive acceptance of failure. Science education leaders must guard against such self-defeating attitudes and provide institutional support for teachers' high expectancies. Teachers must feel they are supported in holding all students to high academic standards and in presuming that students possess ample abilities. Fonseca and Conboy (1999) report a case study of an intervention with introductory physics students fraught with negative attitudes and repeated failure. The experience showed that continuous engagement of the students within meaningful contexts and in a supportive environment (characterized by personal commitment on the part of the teacher, high teacher expectancies and clear objectives and policies), can improve student performance. The study offers insights and suggestions on strategies to improve students' knowledge, competence and expectancies.

Parental involvement is not a panacea for the problem of academic failure. Even so, leaders of the education community must also encourage parental involvement in the learning process and promote the perception among students that parents are involved. The involved parent is not necessarily the parent who attends school meetings. Involved parents know their child's strengths and weaknesses; inform themselves of the date of their child's next evaluation; are aware of what homework there is and when it is due. Once again, the general culture of high expectancies will encourage parents in this role.

Previous academic preparation may be well beyond the reach of the science educator and school leader. We cannot be expected to alter the past or influence what is carried out in, sometimes distant, schools. However, the findings in this study describe an association between achievement and the *perception* of previous preparation. This perception can be influenced in at least two ways: first, through the actual knowledge of how good or poor the previous preparation was, and second, through the social-cognitive evaluation of the previous preparation. We submit that the most probable source of the perception, on the part of students, of the quality of previous academic preparation is to be found in teachers who complain openly about their students' lack of previous preparation—a common practice and probably as old as the profession of teaching. The students may internalize these comments and employ them as convenient, ego-protecting excuses for failure. Science educators and school leaders, then, should encourage science

teachers to refrain from such musings. Once again, the general environment of high expectancies will be strengthened by not providing the students with easy excuses.

Perhaps the most important factor, and one of the most difficult to influence directly, is the quality of teaching. Students readily recognize if their teachers are effective or ineffective. Educational leaders may not be privy to the same level of knowledge of the competence of their teaching staff. How can they know— how can they control— the quality of their teachers? The principal mechanisms for dealing with teaching quality are hiring practices and evaluations. Unfortunately, both processes may be subject to extraneous influences that weaken their efficacy. Teachers may be hired for the wrong reasons, and may be retained, or even promoted, for motives unrelated to teaching proficiency. Given the inherent weaknesses in systems of assessment of teacher effectiveness—a concept quite difficult to operationalize—the promotion of professional development activities is paramount for the improvement of teaching quality. Current science reform documents (National Research Council, 1996, 2002) emphasize the importance of quality of teaching and of quality of professional development, and talk about teacher development as a channel for influencing student learning and academic success

While not identified as a major factor associated with failure in this study, other studies have pointed to the physical conditions and organization of schools as facilitators or inhibitors of the construction of a culture of success. Reasonable lab conditions, good school organization, and even details such as classroom decoration can be an important element in improving student interest and achievement in science. For example, schools can portray positive images (through posters, news stories, video presentations, student projects and awards) that present science careers as attainable, and scientific knowledge as pertinent and contributing to a better life (Buxton, 2005; Hammond, 2001; Zacharia & Barton, 2004).

In this paper we looked at student perceptions of failure and associated them with a series of relevant variables. The collection of small associations encountered in this study is suggestive of a complex and multifaceted system that constitutes the problem of academic failure in secondary schools. The results are in general conformity with previous studies and point to the need for higher teacher expectancies in a supportive learning environment. While we must be attentive to the factors identified by students as causes of failure (quality of science teaching, previous student preparation), educators and administrators should also recognize the opportunity for influencing student behavior through strategies that promote effort.

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REFERENCES

Anthony, G. (2000). Factors influencing first-year students success in mathematics. *International Journal of Mathematical Education in Science and Technology*, 31(1), 3-15.

Buxton, C. (2005). Creating a culture of academic success in an urban science and math magnet high school. *Science Education*, 89(3), 392-417.

Ballone-Duran, L., Czerniak, C. & Haney, J. (2005). A study of the effects of a LSC project on scientists' teaching practices and beliefs. *Journal of Science Teacher Education*, 16(2), 159-184.

Carreira, T., & André, J. (2000). Transição do ensino "obrigatório" para o ensino "voluntário": Algumas causas de crise [Transition from "compulsory" education to "voluntary" education: Some causes of the crisis]. *Educação Indivíduo Sociedade*, 1(1), 123-142.

Covington, M. (2000). Goal theory, motivation, and school achievement: An integrative review. *Annual Review of Psychology*, 51, 171-200.

Dâmaso, P. (2005). *Governo combate Insucesso escolar* [Government combats school failure]. Online November 2005: http://jn.sapo.pt

Davis, K. (2003). Change is hard: What science teachers are telling us about reform and teacher learning of innovative practices. *Science Education*, 87(1), 3-30.

Desimone, L. (1999). Linking parent involvement with student achievement: Do race and income matter? *Journal of Educational Research*, 93(1), 11-30.

Easton, L. (2002). Lessons from learners. *Educational Leadership*, 60(7), 64-68.

European Commission, *Directorate-General for Education and Culture*. (2000). European report on quality of school education—16 quality indicators. Brussels: EC-DGEC.

Fonseca, J. (2003). De alunos em risco de abandono escolar para alunos com sucesso académico: Um modelo de reforma no contexto internacional [From students at risk to academically successful students: A model for reform in the international context]. *Lusíada Psicologia*, 1(1), 211-236.

Fonseca, J. & Conboy, J. (1999). Introductory physics for non-physics majors—A case study. *Journal of College Science Teaching*, 28(4), 272-277.

GAVE: Gabinete de Avaliação Educacional. (2000). *PISA 2000--Conceitos fundamentais em jogo na avaliação de literacia científica e competęncias dos alunos portugueses* [Fundamental concepts in the evaluation of scientific literacy of Portuguese students]. Lisboa: Ministério de Educação.

GAVE: Gabinete de Avaliação Educacional. (2001). Resultados do estudo internacional PISA 2000 [Results of the international study PISA 2000]. *PISA 2000 National Reports*. Online November 2005: http://www.pisa.oecd.org

Gentry, M., & Springer, S. (2002). Secondary student perceptions of their class activities regarding meaningfulness, challenge, choice and appeal: An initial validation study. *Journal of Secondary Gifted Education*, 13, 192-204.

Green, S. B. (1991) How many subjects does it take to do a regression analysis? *Multivariate Behavioral Research*, 26, 499-510.

Hammond, L. (2001). Notes from California: An anthropological approach to urban science education for language minority families. *Journal of Research in Science Teaching*, 38(9), 983-999.

Insucesso escolar afecta um em cada tręs alunos [School failure affects one in three students]. (2004, October 14). *Correio da Manhă*. Online November 2005: http://www.correiodamanha.pt

Kozoll, R., & Osborne, M. (2004). Finding meaning in science: Lifeworld, identity and self. *Science Education*, 88(2), 157-181.

Ministério da Educação. (2002). *Os números da educação no recenseamento—Os números do abandono escolar* [The numbers of education in the census—The numbers of school dropout]. Online November 2005: http://www.min-edu.pt

National Center for Educational Statistics. (2003). *NAEP Report.* Washington, DC: U.S. Department of Education.

National Research Council (1996). *National science education standards*. Washington, DC: National Academy Press.

National Research Council (2002). *Investigating the influence of standards: A framework for research in mathematics, science and technology education*. Washington, DC: National Academy Press.

OECD. (2004). *Learning for tomorrow's world—First results from PISA 2003. Science performance in PISA 2003*. Online November 24, 2005: http://www.pisa.oecd.org

Onwuegbuzie, A. J., & Daniel, L. G. (2003, February 19). Typology of analytical and interpretational errors in quantitative and qualitative educational research. *Current Issues in Education* [On-line], 6(2). Online November 23, 2005: http://cie.ed.asu.edu/volume6/number2/

Rayneri, L., & Gerber, B. (2004). Development of a student perceptions inventory. *Roeper Review*, 26(2), 90-95.

Tucker, C., Herman, K., Pedersen, T., Vogel, D., & Reinke, W. (2000). Student-generated solutions to enhance the academic success of African-American youth. *Child Study Journal*, 30(3), 205-221.

Weiner, B. (1980). *Human motivation*. New York: Holt, Rinehart & Winston.

Weiner, B. (1986). *An attributional theory of motivation and emotion*. New York: Springer-Verlag.

Whitelaw, S., Milosevic, L., & Daniels, S. (2000). Gender, behaviour and achievement: A preliminary study of pupil perceptions and attitudes, *Gender and Education*, 12(1), 87-113.

Wong, E., Wiest, D., & Cusick, L. (2002). Perceptions of autonomy support, parent involvement, competence and self-worth as predictors of motivational orientation and academic achievement: An examination of sixth- and ninth-grade regular education students. *Adolescence*, 37(146), 255-266.

Yore, L., Anderson, J. and Shymansky, J. (2005). Sensing the impact of elementary school science reform: A study of stakeholder perceptions of implementation, construtivist strategies and school-home collaboration. *Journal of Science Teacher Education,* 16 (1), 65-88.

Zacharia, Z., & Barton, A. (2004). Urban middle-school students' attitudes toward a defined science. *Science Education*, 88(2), 197-222.

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