alumbra mucho. La sombra que se ve con la bombilla que alumbra poco es, respecto a la de la bombilla que alumbra mucho:

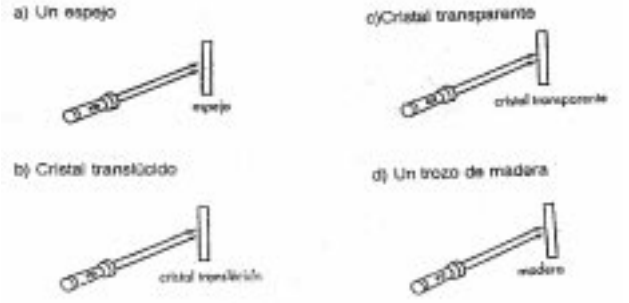
a) más grande,

b) del mismo tamaño,

c) más pequeña.

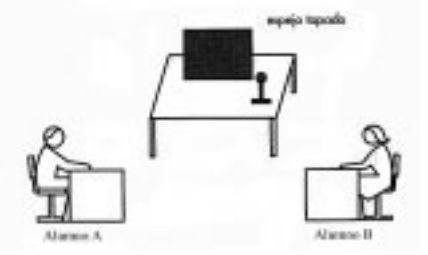
Escoge una opción y explica porqué lo haces.

5. Explica y pinta flechas en los dibujos siguientes para mostrar qué ocurrirá a luz de una linterna después de chocar con los siguientes objetos:



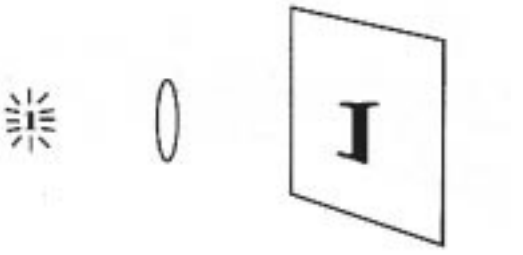
6. ¿Por que tenemos que mirar un objeto para verlo?

7. En la figura permanece el espejo tapado. Si destapamos el espejo, la persona situada en A, ¿puede ver la bola en el espejo? La persona que está sentada en B, ¿puede ver la bola en el espejo? Responde a las dos preguntas y da una explicación.



8. Explica mediante un diagrama de rayos qué imagen obtendrás en un espejo cóncavo si situamos el objeto en la distancia focal. ¿Para qué se utiliza este tipo de espejos?

9. Supón que quitas la lente. ¿Qué imagen ocurrirá en la pantalla?



10. La luz de una linterna produce una mancha blanca sobre la pared. Si le ponemos a la linterna un filtro rojo, aparece una mancha roja sobre la pared. ¿Qué ha ocurrido en este proceso? Escoge una opción y explica porqué la escoges.

a) La luz blanca se colorea de rojo en el filtro.

b) La luz blanca es absorbida y la luz roja es emitida por el filtro.

c) El filtro sólo permite pasar a la luz roja a su través.

d) Otra explicación.

11. Obtener gráficamente la imagen de un objeto producida por un lente convergente cuando dicho objeto se encuentra muy alejado del foco.

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Training in study-methods: contributions to students' self-regulation in natural science learning

Instrucción en métodos de estudio: contribuciones a la autorregulación de los estudiantes en el aprendizaje de ciencias naturales

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Abstract

The relevance of strategies of study becomes very important, especially when learning difficulties partially explain low levels of literacy in students and hinder adequate developments of citizenship. This article presents an intervention program directed at teaching strategies of study and follows with the presentation of its evaluation. The program is directed to students enrolled in the last 3 years of compulsory school in Portugal (between 11 and 15 years old), and it includes four domains: 'Personal Perceptions and Involvement in Studying', 'Attitudes and Behaviour in Studying', 'Competence and Cognitive Processes in Studying' and 'Attitudes and Behaviour in Evaluation Situations'. The persistent concern of teachers with the student's academic failure, and the difficulties perceived in the process of studying of students enrolled in the Portuguese compulsory school, justify this research in the area of teaching and self-learning in Natural Sciences.

Keywords*: Self-regulation, Self-learning, Natural Sciences*

Resumen

La relevancia de las estrategias de estudio es muy importante, sobre todo cuando las dificultades en el aprendizaje explican parcialmente los bajos niveles de analfabetismo en estudiantes, y dificultan desarrollos adecuados para la ciudadanía. Este artículo presenta un programa de intervención dirigido a la enseñanza de estrategias de estudio y sigue con la presentación de sus estudios de validación. El programa se dirige a estudiantes matriculados en los 3 últimos años de la enseñanza secundaria obligatoria en Portugal (entre los 11 y 15 años), y esto incluye cuatro dominios: percepciones personales y participación en el estudio, actitudes y comportamiento en el estudio, capacidad y procesos cognoscitivos en el estudio, y actitudes y comportamiento en situaciones de evaluación. La persistente preocupación de los profesores con el fracaso académico del estudiante, y las dificultades percibidas en el proceso de estudio de los estudiantes matriculados en la enseñanza obligatoria portuguesa, justifica esta investigación en el área de enseñanza y autoaprendizaje en ciencias naturales.

Palabras clave: autorregulación, autoaprendizaje, ciencias naturales.

INTRODUCTION

Recent research points to learning strategies and studying as necessary elements for a successful academic learning process. It is recognised that by resorting to a studying method the student becomes more responsible for his/her own process of learning, allowing him/her to accomplish innovation, in his/her professional and private life Thus, s/he becomes more capable of giving a better response to the demands of new information or education. On the other hand, the absence of an effective study-method

leads many students to academic failure, despite their hard efforts to study (WEINSTEIN & MAYER, 1986). Accordingly, some academic failures can have positive outcomes and in due course can be prevented, as long as students are taught to think and learn to study. This reasoning determines that *learning to learn* is of capital interest to educational system. Self-learning is understood as a necessary component for improving the process of studying and making it more efficient. By enhancing autonomy and success, the practice of studying strategies will reflect on new sources of motivation for new and more complex processes of learning, self-awareness of success and failure and habits of self-regulation throughout schooling. Following this reasoning, this study presents the AME Program (***A**prender **M**étodos de **E**studo* - Learning Methods of Study - VASCONCELOS, 2000), conceived as an instrument to achieve the awareness, training or the development of study methods, within school learning contexts, among students between 11 and 15 years old. The program does not aim to present magic solutions but rather to promote dialogue, debate and co-operation, as well as to forge educational cooperation between students. These activities will promote interaction and learning through tutorial sessions, thus enhancing self-regulation, that is, enhancing the autonomy of the student in his/her studying and learning endeavours (WOOD *et al.*, 1976; WEBB, 1982; ZIMMERMAN, 1990). Students self-learning can be achieved by using specially prepared didactic materials and by using methods of self-education in independent student work (RUDZITIS, 2000). The program is conceived in direct articulation with the Natural Sciences curricula, although the incursion and transfer of competence from/to other subjects is encouraged.

In the social-cognitive perspective, supported especially by SCHUNK (1989), ZIMMERMAN (1989) and BANDURA (1993), self-regulated learning is understood as an emerging construct from the self-created behaviour of students, systematically directed to objectives that students themselves, stipulate, modify or maintain (ZIMMERMAN, 1989). Although other theoretical perspectives regarding self-regulation in learning can be mentioned, all of these present common characteristics:

(i) self-regulated subjects resort to the systematic use of meta-cognitive, motivational and/or behavioural strategies;
(ii) a cyclic process exists through which the student monitors the efficacy of his/her methods or strategies of learning: self-oriented circular *feedback*;
(iii) a motivation dimension exists that determines the how and why of the student's choice of a specific strategy (although, according to the theoretical perspective followed here, the motivation dimension emphasises the expected result in a different way);
(iv) self-regulated learning depends on the context, personal effort and results of performance or achievement.

According to this conceptualisation of self-regulation in learning, the students are pro-active in meta-cognitive, motivational and/or behavioural terms, thereby regulating their own processes of learning (WEINSTEIN, 1988; ZIMMERMAN, 1989, 1990; ZIMMERMAN & MARTINEZ-PONS, 1986; ZIMMERMAN *et al.*, 1992; BANDURA, 1993; PINTRICH & DE GROOT, 1990; DÍAZ *et al.*, 1990; WITTROCK, 1988). Research over recent years has described some strategies of self-regulation in learning, frequently used by students. A study developed by ZIMMERMAN and MARTINEZ-PONS (1986) has allowed the description of fourteen types of strategies of self-regulation in learning. Some of those strategies aim to optimise personal regulation, by profiting from students' ability to manage competencies (that is, for example, the *strategies of organisation and transformation of information, repetition and memorisation, establishment of objectives and planning*), others improve their functional behaviour (strategies such as *self-evaluation* or *self-consequences*). Finally, the author refers to the *strategies of environmental structure,* the *search for information,* the *revision* and *search for social help,* as useful strategies for improving the direct learning environment of the student. These self-regulation learning strategies that can be taught to the students include: managing time; studying materials; self-evaluation attitudes; effort and achievement; competencies in organization and transformation; analysis and selection of information. All such strategies are usually contemplated in programs for cognitive and study methods training. Under this framework, the general characteristics of the AME Program are presented and the dynamics and structure of the sessions are described.

The Program's Learning Methods of Study

This program was structured in nine sessions, eight with an estimated length of 100 minutes, corresponding to double teaching periods and one session of 50 minutes. The activities that are presented focus on contents related to the Natural Sciences curriculum which is an area of academic interest to the authors. However, other *curricula* contents are also deliberately used in one or two sessions, thereby indicating to the students that the study methods may be applied to quite different areas and subjects. Throughout the program and following the teacher's manual, the students are directed to engage in specific cognitive processes and in the development of study-skills or habits. Accordingly, one of the program sessions addresses the dimension *Personal Perceptions and Involvement in Studying*, which encompasses variables like: motivation, self-efficacy and casual attribution. The Program further presents three major intervention areas, named as *Attitudes and Behaviour in Studying (time, space and studying materials), Competence and Cognitive Processes in Studying (comprehension, memorization, acquisition of information),* and *Attitudes and Behaviour in Evaluation Situations (*behaviour that is previous, during and after testing).

The choice of these components was determined by the wish to implement a Program that would allow the AME Scale[1] (*Avaliar Métodos de Estudo* – Evaluating Methods of Study- VASCONCELOS, 2000) to be completed, which was constructed and validated in a previous study[1]. Thus, following the diagnosis of some learning difficulties and with the help of the Scale, the partial or total application of the Program may be supportive of the students' correction of *deficit areas*. Regardless of the dimension to which each session refers, the following objectives underlie all of them:

(i) the practice of study strategies or the practice of processes specific to the method of study in that specific session;
(ii) the practice, understanding and meta-cognitive reflection of the domains and dimensions of each session; and
(iii) the transfer of the tasks and training of the session to other personal contexts of study, for example, a typical classroom or to an individual studying situation at home.

The ultimate objective of the program was to grant each student a personal method of study that would perpetuate the effectiveness of the program's intervention.

This paper refers two studies related to AME Program validation. Two studies were carried out to apply and validate the AME Program. The first study, considered a pilot study, was established with the experimental version of that program. In the final version, new activities were developed and integrated in the sessions of the dimension *Personal Perception and Involvement in the Study*, in which enrichment was perceived as necessary, since the impact of the program was less significant in the pilot study. On the other hand, the number of activities in the dimension *Competence and Cognitive Processes* was increased, thereby strengthening the application to scientific Natural Sciences contents. Therefore, we present the data from the second study (quasi-experimental study) as follows:

METHODOLOGY

Subjects

The sample of the quasi-experimental study was composed of 118 students enrolled in the 3rd cycle of a public school, in Portugal. These were students from the 7th (43.2%), 8th (29.7%) and 9th (27.1%) grade, of both gender (51.7% girls). The students were between 11 and 15 years old, in the 7th grade, between 12 and 16, in the 8th grade, and between 13 and 16 years in the 9th grade. From the total sample, 59 students made up the control group and the remainder formed the experimental group. Within the first group, the average age was 13.1 and in the second, 13.5. The subjects that made up the experimental group were all volunteers, picked at random among the classes that accepted participation in the program. Both groups were mostly formed by students from the 7th grade.

Instrument

As instruments for the pre and post tests, the intervention resorted to the Scale of Evaluation of the Methods of Study (Scale AME - VASCONCELOS, 2000). The authors applied the AME Program in its final version to the experimental group, within the school context, during the first term[2]. The students (both within the experimental and control group) were asked to give information related to the classifications that they obtained in Portuguese, Mathematics and Natural Sciences before and after training program (classifications in a scale from 1 to 5 points).

Results

Means and standard deviation are presented at table I for different dimensions scores and considering both groups, and pre- and post-tests. An analysis of variance (ANOVA) was established, with two factors (groups and tests) and repeated measures were undertaken, taking the results obtained in the different dimensions of the AME Scale as the dependent variable.

Table I. Mean and standard deviation in both groups

Dimensions	Experimental Group		Control Group	
	pre-test M(SD)	*post-test* M(SD)	*pre-test* M(SD)	*post-test* M(SD)
Motivation	64.6 (6.70)	75.4 (8.54)	67.1 (10.60)	67.6 (10.69)
Self efficacy	34.2 (5.07)	43.2 (5.99)	36.5 (5.38)	38.2 (6.18)
Causal attributions	40.0 (5.09)	47.4 (3.88)	42.0 (6.11)	42.5 (5.86)
Space	47.2 (4.40)	54.6 (4.94)	49.4 (6.59)	49.4 (6.88)
Material	48.0 (5.44)	55.1 (7.94)	49.6 (6.12)	49.3 (7.67)
Time	38.7 (4.24)	44.7 (6.65)	39.3 (6.32)	39.1 (6.94)
Acquisition of information	49.1 (5.17)	56.7 (7.31)	51.2 (6.96)	50.3 (7.97)
Comprehension	54.4 (5.24)	63.9 (8.72)	55.8 (7.45)	56.0 (8.35)
Memorisation	32.2 (3.95)	38.3 (6.11)	34.0 (5.84)	33.7 (5.84)
Tests	41.9 (4.40)	48.9 (6.04)	43.6 (5.34)	42.8 (6.08)

Legend: M= mean; SD = standard deviation.

In all dimensions we assist to significant interactive effects ($p<0,001$) between the two factor (groups and testes). F values obtained for the ten subscales were: motivation ($F=51,14$; $p<0,001$); self efficacy ($F= 54,90$; $p<0,001$); causal attributions ($F=50,40$; $p<0,001$); space ($F=62,66$; $p<0,001$); material ($F=32,79$; $p<0,001$); time ($F=30,05$; $p<0,001$); acquisition of information ($F=46,19$; $p<0,001$); comprehension ($F=48,54$; $p<0,001$); memorisation ($F=35,50$; $p<0,001$); tests ($F=59,42$; $p<0,001$). These effects mean a difference between both evaluation times (pre- and post-tests), indicating an increase of results on post-test. At same time, results are different if we consider both groups. In effect the experimental group presents higher values in all dimensions (see table I). These values show a positive effect of program for training study methods. Accordingly, it is legitimate to accept that those students that were engaged in the AME Program significantly improved their study methods, in accord with different dimensions of AME Scale.

Finally, the study attempted to find out if the students that acquired better methods of studies, also managed to improve their academic performance. Table II describes the academic performance of both groups before and at the end of the training Program.

Table II Academic performance in both groups

Moments	Groups	Portuguese M (SD)	Maths M (SD)	Natural Sciences M (SD)
Pre-test	experimental	3.3 (0.75)	3.3 (0.87)	3.5 (0.75)
	control	3.2 (0.81)	3.0 (0.73)	3.4 (0.81)
Post-test	experimental	3.2 (0.73)	3.1 (0.67)	3.8 (0.63)
	control	3.2 (0.73)	3.1 (0.63)	3.3 (0.48)

Legend: M= mean; SD = standard deviation.

We notice a stability of school grades in both groups and test. A paired sample t-test shows a significant effect only for the experimental group and only in Natural Sciences, when we compare the two moments ($t=-2.09$; $p<0.05$). This result suggests a slight positive effect of program, although the mean difference is low. In other words, those students that were engaged in the AME Program improved their academic performance only in Natural Sciences. The absence of significant improvements in the experimental group in Portuguese and in Mathematics, may be related to problems related to the generalisation of learning. Indeed, the AME Program primarily focused and resorted to Natural Sciences contents. On the other hand, one is aware that the intervention did not consider aspects such as previous significant and wide learning, or specific demand at the level of the contents taught in Mathematics and Portuguese.

CONCLUSIONS

Apart from students' cognitive variables, other determinants attempt to explain the reasons for academic failure. As previously mentioned, JIMÉNEZ (1997) directly refers to pedagogical, affective and intellectual factors, as well as factors related to the social context of the individual. Nonetheless, by enhancing the role of the student in the process of learning (ZIMMERMAN, 1990; MAYER, 1992), some form of intervention may be sought to improve the process of learning. As such, a wide range of promising research has developed in the area of self-learning. Such research reinforces the need for, and signals the absence of, learning about strategies of study. This deficiency may be the reason for the differences in learning and academic performances. Internationally, as well as in Portugal, some programs have emerged that focus on cognitive training and practice of study methods (see HAMERS & OVERTOOM, 1998). The application of the AME Program proved to be useful in the promotion of study methods, therefore demonstrating the adequacy of its structure and implicit techniques and activities. Nonetheless, the statistical procedures that were undertaken led to the conclusion that the intervention at the level of the improvement of academic performance, was only marginally effective in Natural Sciences. This raises the issue of generalising skills beyond the subject used in training. The ultimate objective of the program was to endow each student with a personalised method of study, by knowing how to choose from different strategies whenever a task needed to be performed. Only the *de facto* acquisition of that method of study will allow the effective continuity of the established intervention. However, this is only possible if accompanied by a persistent and shared action of the different intermediary in the educational process and even so, it still depends on the availability and receptiveness of the student to that process of learning.

Notes

1 – The AME Scale is a scale for the diagnosis of study methods. It is composed of 125 items, organised in *Likert* type format, with five answer possibilities: 1) never, 2) seldom, 3) sometimes, 4) often, 5) always. The items are distributed in the 4 dimensions that make up the AME Program: (i) Personal perceptions and involvement in studying, (ii) Attitudes and behaviour in Studying, (iii) Competence and Cognitive Processes in studying, and (iv) Attitudes and behaviour in Evaluation Situations.

2 – In Portugal, students are assessed in quantitative terms, at the end of three academic terms: (i) end of the 1st trimester – December; end of the 2nd trimester – April, and; (iii) end of the 3rd trimester – July.

BIBLIOGRAPHY

BANDURA, A., Perceived self-efficacy in cognitive development and functioning. *Educational Psychologist*, 28 [2], 117-148, 1993.

HAMERS, J.H.M. & Overtoom, M.T., Programas europeus de ensinar a pensar: Tendências e avaliação, *Inovação*, 11 [2], 9-25, 1998.

JIMÉNEZ, B.T., *Del fracaso al éxito escolar*, Plaza & Janés Editores, Barcelona, 1998.

MAYER, R.E., *Thinking, problem-solving, cognition*, CA: Freeman, San Francisco, 1992.

PINTRICH, P.R. & DE GROOT, E.V., Motivational and self-regulated learning components of classroom academic performance, *Journal of Educational Psychology*, 82 [1], 33-40, 1992.

RUDZITIS, G., System for preparing high school learners and students for self-education, *Journal of Science Education*, 1, [1],17-20, 2000.

SCHUNK, D., Self-efficacy perspective on achievement behaviour, *Educational Psychologist*, 19 [1], 48-58, 1984.

VASCONCELOS, C., *Métodos de estudo em alunos do 3º ciclo do ensino básico: um contributo à intervenção educativa dos professores*, tese de doutoramento, Braga, Universidade do Minho, 2000.

WEBB, N.M., Student interaction and learning in small groups, *Review of Educational Research*, 52 [3], 421-445, 1982.

WEINSTEIN, C.E., Assessment and training of students learning strategies, in R.R. SCHMECK (ed.), *Learning strategies and learning styles*, Plenum Press, New York, 1988.

WITTROCK, M.C., A constructive review of research on learning strategies, in C.E. WEINSTEIN, E.T. GOETZ & P.A. ALEXANDER (eds.), *Learning and study strategies*. Issues in Assessment, Instruction and Evaluation, Educational Psychology Series, Academic Press Inc, San Diego, 1988.

WOOD, D., BRUNER, J.S. & ROSS, G., The role of tutoring in problem solving, *Journal of Child Psychology and Psychiatry*, 17 [2], 89-100, 1976.

ZIMMERMAN, B.J., A social cognitive view of self-regulated academic learning, *Journal of Educational Psychology*, 81 [3], 329-339, 1989.

ZIMMERMAN, B.J., Self-regulated learning and academic achievement: An overview. *Educational Psychologist*, 25 [1], 3-17, 1990.

ZIMMERMAN, B.J., BANDURA, A. & MARTÍNEZ-PONS, M., Self-motivation for academic attainment: The role of self-efficacy beliefs and personal goal setting, *American Educational Research Journal*, Fall, 29 [3], 663-676, 1992.

ZIMMERMAN, B.J. & MARTÍNEZ-PONS, M., Development of structured interview for assessing student use of self-regulated learning strategies, *American Educational Research Journal*, 23 [4], 614-628, 1986.

ZIMMERMAN, B. J. & MARTÍNEZ-PONS, M., Student differences in self-regulated learning: Relating grade, sex, and giftedness to self-efficacy and strategy use, *Journal of Educational Psychology*, [82], 51-59, 1990.

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