A Computer Assisted Intervention on Learning Strategies

António Duarte and Alexandra Barros

University of Lisbon

Abstract

The objective of this study, in the Student Approaches to Learning (SAL) perspective, was to test a computer-assisted intervention that seeks to promote awareness and self-regulation of learning strategies, aiming at improving the quality of learning. The intervention involved the use, by a sample of higher education students, of purposely developed interactive software – the PAE v.1 - which basically allows users to self-assess, recognize and self-regulate learning strategies. Pre- and post-intervention measures of the learning process and product were compared, both in general and individually, according to the experimental methodology. The results suggest that the intensive implementation of the intervention was effective in generally increasing a deep learning strategy and, in some cases, reducing a surface strategy and increasing an achieving strategy, but not significantly enough under these conditions, to improve the quality of learning. It is suggested a way of using the intervention procedure to achieve such an improvement.

Introduction

Student Approaches to Learning (SAL) theory suggests that learning products result from a variety of factors: students' characteristics, their learning context and, more directly, their learning process (Biggs, 1999; Biggs & Tang, 2007). This theory conceptualizes the learning process as an interaction between the kinds of motivation that support learning and the types of strategies that actualize it (Entwistle, Tait & McCune, 2000; Marton & Säljö, 1976).

Motivation refers here to what orients a student to learn. Learning strategies, the focus of this empirical study refers to all means a student uses to cope with learning tasks – especially to process information. In this sense, Biggs (1984) differentiated three levels of strategies: "micro", "macro" and "meso". "Microstrategies" are the elementary procedures directly used to study (e.g., note-taking), while "macro strategies" are responsible for self-regulating those procedures (e.g., monitoring and modifying note taking). In addition, on an intermediate level,

"meso-strategies", the focus of SAL theory, characterize the manner in which micro-strategy are used (e.g., literal or selective note-taking). Specifically, research has identified three kinds of meso-strategies: surface, deep and achieving strategies (e.g., Biggs, 1987; Diseth, 2013). The use of a surface strategy basically involves dealing separately with content units, therefore not interconnecting them or connecting them with other content, and literally memorizing formal elements such as words, facts or procedures. In contrast, the use of a deep strategy mostly implies interrelating content and relating it to prior knowledge in an attempt to understand and eventually develop a critical position. Third, the use of an achieving strategy involves managing one's study in an organized way while considering evaluation criteria.

Approaches to learning can act both as stable ways of addressing study tasks by relying on individual characteristics and as varied responses to situations depending on the context (e.g., Biggs, Kember, & Leung, 2001). Therefore, consistency in learning does not nullify the possibility of alternating between different approaches to learning as a function of an individual's perception of content, context, external expectations or type of learning task (Laurillard, 2005; Richardson, 2007).

1.1 Learning Strategies and Quality of Learning

In attempting to characterize the quality of learning, several systems have been proposed (e.g., Bloom, 1956; Marton & Säljö, 1976).

Inspired by Piaget's perspective and the SAL framework, Biggs and Collis (1982) propose the SOLO taxonomy (Structure of the Observed Learning Outcome), which attempts to differentiate the expression of preoperational, concrete and formal thinking on the learning product. Biggs and Collis (1982) suggest that any answer to a question on learned content involves three parameters: "relating" (i.e., logical connection with the question); "capacity" (i.e., addressed information); "consistency and closure" (i.e., how it concludes). By observing how these parameters vary in different learning products, a taxonomy that characterizes five levels of increasing complexity was developed: 1. pre-structural (absence of a logical connection between an answer and corresponding question, which is repeated or answered in an irrelevant way; the conclusion is inconsistent with the original information); 2. uni-structural (the answer is logically connected to the question, but it includes only one correct and relevant informational unit; the conclusion is impulsive and inconsistent); 3. multi-structural (the answer is logically connected to the question with several relevant but not interrelated informational units that enumerate or repeat acquired information; the conclusion is impulsive and inconsistent); 4. relational (the answer is logically connected to the question with several relevant integrated informational units in the form of a concept or argument; the conclusion is consistent with learned information); and 5. abstract (the answer is logically connected to the question and also possibly to the hypothetical questions; the information is interrelated, and the general principles are made abstract for other knowledge domains; the conclusions are open, providing logically possible alternatives). In addition to these five levels, it is also possible to consider the intermediate level and intra-level differentiations, although Biggs and Collis (1982) consider these to be less relevant discriminations in terms of assessing significant differences in the quality of learning. The SOLO taxonomy is applicable to the characterization

of learning in different knowledge areas and has been used in the study of the relationship between the learning process and learning products (e.g., Biggs, 1999; Biggs & Tang, 2007; Zou et al., 2014).

In parallel, different studies have focused on the relationship between approaches to learning and learning products. Some of these studies consider how the use of each approach to learning relates to achievement, and they basically have found that while deep and achieving approaches to learning tend to positively relate to or even predict academic achievement, the surface approach tends to negatively relate to it or even predict underachievement (Cano, 2005, 2007; Diseth, 2007, 2013; Phan, 2009; Platow, Mavor & Grace, 2013; Watkins, 2001). A few studies with the same focus report a null effect of deep or surface approaches on academic performance (e.g., Phan, 2007), but this finding has been explained by the possible misalignments between assessment tasks and learning outcomes (Phan, 2009). Moreover, other studies have considered how the use of each approach to learning relates to learning products with differentiated levels of structural complexity. These studies reveal that approaches to learning in which the surface strategy is involved tend to be associated with learning products of more reduced structural complexity – i.e., multi-structural in terms of the SOLO taxonomy (e.g., Biggs, 1987; Van Rossum & Schenck, 1984; Watkins, 1983). The surface approach to learning might lead to difficulties with integrating parts of the content, which are consequently separately processed in their presented order. In contrast, the studies reveal a typical association between approaches to learning that involve the deep strategy and higher levels of structural complexity of the learning product. Effectively, the use of the deep approach to learning is related to products at the relational level (characterized by the interrelation of content based on the development of personal arguments on the theme) and products at the abstract level (characterized by the same interrelation and by generalization to other domains) (e.g., Biggs, 1987; Gibbs, 1992; Trigwell & Prosser, 1991; Zou et al., 2014). This supports the argument of Liping Chen and Dhillon (2012) that the use of a deep approach facilitates the transfer of learned concepts to a variety of situations due to the denser matrix of connections within personal knowledge. Finally, concerning approaches to learning that involve an achieving strategy, there are signs that they can relate to learning products of high (Zou et al., 2014) but also diversified structural levels (Biggs, 1987). In this case, it is conceivable that the product might "strategically" vary depending on the students' perception of the situation's utility, which is based on their aims (i.e., high grades) or what will possibly please the teacher.

The association between approaches to learning (where different types of strategies are involved) and different learning products creates possibilities to improve these products by impacting these former variables.

1.2. Improving Learning

Complementing descriptive studies that address students' approaches to learning, research is also interested in the modifiability of these approaches in an attempt to develop ways to improve learning. This kind of applied research has produced mixed results, and a significant number of interventions suggest the possibility to evoke desirable changes in approaches to learning (Richardson, 2005).

One initial perspective, centred on the modification of the learning context, suggests that an intervention's goal should be to encourage deep and achieving approaches to learning while discouraging the surface approach to learning. In this line, several studies have demonstrated the possibility to intervene in order to encourage the use of a deep approach to learning (e.g., English, Lucket & Mladenovic, 2004; Liping Chen & Dhillon, 2012). This goal is justified based on the fact that the deep and achieving approaches normally lead to a higher level of learning product than the surface approach (e.g., Platow et al., 2013; Trigwell & Prosser, 1991). The same goal might also be grounded in the fact that instruction, especially in higher education, is mostly aimed at students' demonstration of conceptual comprehension and independent learning (Wilson & Fowler 2005).

Another perspective, centred on the modification of personal variables, suggests that a surface approach to learning in certain situations can be more adaptive; the goal of interventions should be neither encouragement nor discouragement of any approach to learning but the promotion of self-awareness and self-regulation in all approaches to learning (e.g., Blundell, 1995). This self-regulation acts considering the situational demands, improving the probability of a reflective and adaptable approach to the learning task. Accordingly, several studies indicate the advantages of promoting awareness of both implemented and alternative approaches to learning, along with promoting knowledge of the consequences of adopting each variety of approach (Beckwith, 1991; Duarte, 2012; Entwistle & Wilson, 1977; Entwistle, Odor, & Anderson, 1987).

The possibility of simultaneously aiming for the two kinds of goals mentioned above is also considered. This means that although it seems legitimate to encourage a deep and achieving approach to learning and discourage a surface approach, it is also necessary to prepare students to regulate their own approach to learning so that they can autonomously adapt to the variety of situations they confront. This means recognizing the advantages of encouraging a deep and achieving approach to learning but also finding that the decision on the approach belongs to the student based on the types of situations with which he/she is confronted. It also assumes that the student knows the different approaches and is aware of the possible consequences of each.

An analysis of the results from interventions on approaches to learning reveals that the efficacy of these results is neither linear nor consistent. For instance, although it is relatively simple to implement a surface approach to learning, it is not easy to encourage a deep approach. Furthermore, some of these interventions seem to be successful only with more mature students (Biggs & Rihn, 1984). After conducting a literature review, Richardson (2005) emphasizes the role of students' perceptions of changes in these approaches to learning along with their conceptions of learning in mediating actual changes in their approach. Nevertheless, a number of interventions suggest the possibility to make desirable changes in approaches to learning, particularly to increase the deep approach to learning (e.g., Bran, 2014; Gibbs, 1992). In addition, a potentially new intervention has also been introduced in this realm with the assistance of computers.

1.3. Computer Assisted Intervention on Approaches to Learning

Interventions on approaches to learning have also reflected the inclusion of information and communication technologies (ICT), particularly specialized e-learning environments (e.g., AK, 2011) and software applications. Regarding the latter, few have been developed and tested, which are briefly reviewed here.

The PASS (Personalized Advice on Study Skills), software developed by Entwistle and collaborators, aims to provide an assessment and acquisition of study skills and counselling in an organized deep approach to learning (Entwistle, Tait & Speth,1998; Tait & Entwistle, 1996; Tait, Speth & Entwistle, 1995; TLTP, 1998). This tool allows for automatic evaluation of users' learning competencies - including their approaches to learning - along with counselling on the competencies needed for academic adaptation. Another version of PASS was later developed for online use, making it accessible to a wider range of students (McCune, 1999).

The IECM (Integrated Engineering Course Map) is an application designed by Solomonides (1993) for use by engineering students (Solomonides & Swanell, 1995). Among other topics, this software introduces different types of motivation to study, different conceptions of learning (prioritizing a "qualitative" conception) and different approaches to learning. The application also provides instruction on the competencies needed to apply a deep approach to learning (both in general and specifically related to learning by reading and for examinations).

Finally, the Skills Shop is an application developed by Bailey, Catchpole and Smart (1997) for use by university students as well. This software presents the different approaches to learning and discourages the use of a surface approach to learning while encouraging a deep and achieving approach. It promotes the development of different learning strategies by providing tutoring on time management, classroom learning, reading, writing, reviewing and project work.

The goal of this study was to contribute to the validation of a new specialized software the PAE v.1 (i.e., an environment to intervene on learning strategies, which was developed within the framework of the SAL theory by examining its impact on learning strategies and the quality of learning in a sample of college students. The main goals of the PAE v.1 are as follows: promoting or maintaining its users' learning strategies that maximize learning results (i.e., in general, a low surface learning strategy and a highly deep and achieving learning strategy) and increasing its users' quality of learning (i.e., high structural complexity of learning products). Therefore, concerning the impact of the PAE v.1, the four hypotheses were established as follows: H1- After the use of the PAE v.1, there will be a general reduction of the surface learning strategy and a general increase of the deep and achieving learning strategy among participants in the experimental group; H2 - After the use of the PAE v.1, there will be a general increase in the quality of learning (i.e., increase in structural complexity of learning products) among participants in the experimental group; H3 - In a follow-up observation of participants in the experimental group, the changes predicted in H1 and H2 will be maintained; and H4 - Despite the mean changes predicted in the experimental group in H1 and H2, there will be

individual variability within the sample, with some cases benefiting from the use of the PAE v.1 while others do not.

2. Method

2.1. Procedure

A before-after experimental design (Christhensen, 2007) was used to evaluate the impact of the intervention using the PAE v.1 (independent variable) on learning strategies (dependent variables) (H1). The learning strategies of the experimental group (that used the software) and control group (that did not use the software) were evaluated before (pretest) and after the intervention (posttest) and then later, in a follow-up (H3) of solely the experimental group. Participants in these groups were students from the same university pursuing the same degree (see Participants) who were randomly assigned to the experimental and control groups.

Additionally, a one-group before-after experimental design (Christhensen, 2007) was used to evaluate the intervention's impact on the software users' quality of learning (dependent variable) (H2). Quality of learning was evaluated before and after the intervention and then later at follow-up.

Moreover, based on a multiple case experimental design (Cristhensen, 2007; Neuman & McCormick, 1995; Wilson, 2000) and from a perspective that emphasizes the interaction effect between "treatment" and "aptitude", a before-after intervention comparison of learning strategies and the quality of learning was performed for each software user, aiming to find evidence that its effects were specific to each person (H4).

2.2. Participants

The sample of students who used the software was composed of 14 freshmen from a Portuguese public university's psychology program: 6 males and 8 females with a statistical mode age of 18 years (M=18.1; SD=.3) and a mean grade in a secondary school of 15.6 (SD=1) on a scale from 0 to 20. The sample of students who participated in the learning strategies control group was also composed of 14 university freshmen from the same psychology program: 3 males and 11 females with a statistical mode age of 18 years (M=20.4; SD=5.2) and a mean grade in secondary school of 15.9 (SD=1.1) on a scale from 0 to 20. No participants dropped out of the study.

Informed consent was obtained after debriefing participants on the study (i.e., procedure and context) and confidentiality.

2.3. Measures and Measurement

The data collection for the evaluation was performed at three-time points: initial evaluation, post-intervention and follow-up. The initial evaluation, in which participants' baseline use of learning strategies and quality of learning were assessed, involved an initial application of the questionnaire's scales on learning strategies and three (1st, 2nd and 3rd) reading tasks (with a one-week interval between each). The post-intervention evaluation, in which the intervention's

impact was measured, occurred one week after the intervention was finished and involved a second application of the scales on learning strategies, along with the application of the other three (4th, 5th and 6th) reading tasks (again with a one-week interval between each). Finally, a follow-up evaluation to estimate the degree to which the intervention results were maintained occurred one month after the last session of the post-intervention evaluation and involved a third application of the scales on learning strategies, along with a final (7th) reading task.

The use of learning strategies was evaluated using three scales on learning strategies from the Inventory of Learning Processes for University Students (IPA-u; Duarte, 2007), an inventory developed for the Portuguese context based on the SAL theory. The implemented version was the 2nd revised version, which had been studied with a sample of 1100 Portuguese university students. This instrument includes 48 items, each measured by a 5-point Likert-type scale ranging from 1 (Never or rarely true to me) to 5 (Always or almost always true to me). Eight factors with eigenvalues higher than 1, accounting for 57.7% of the variance, were found using an exploratory factor analysis followed by varimax rotation. These eight factors corresponded to eight scales, of which four addressed motivation and four addressed learning strategies: Deep Strategy (learning by comprehending, interrelating information and using critical thinking - 8 items, e.g., "i.4. I try to relate different content."); Achieving Strategy 1 - Time (use of time management - 5 items, e.g., "i.10. I try to efficiently organize my study time."); Surface Strategy (rote learning - 6 items, e.g., "i.12. I try to learn most content by memorizing it by heart."); and Achieving Strategy 2 - Difficulties (personal management - 2 items, e.g., "i.32 I have difficulty organizing my work.": inverted item). The Cronbach's alpha values were .88, .83, .80, and .73, respectively. For this study, only the first three aforementioned scales on learning strategies were used.

To evaluate participants' quality of learning, a procedure based on the evaluation paradigm proposed by Biggs and Collis (1982) was used. This paradigm involves categorizing participants' answers to questions about the text they have read (e.g., a question on science-related text is as follows: "Comment on the potential of science as presented in the text"). This categorization is made by locating each answer in a taxonomy of possible answers that provides a characterization of learning products' "structural complexity" (i.e., the SOLO taxonomy with 5 increasing levels of quality of learning, presented in "1. Introduction"). All the texts that are used present open content, allowing answers to cover every level of the taxonomy. Three texts were used for both the initial and post-intervention evaluation. These texts were similar in genre (two informative texts and one fictional text at each time point), length (mean of 368 and 335 words and 14 and 13 sentences), and legibility as measured by the Flesch Reading Ease index (FREI) (Flesch, 1979) (mean values of FREI of 9 and 16). For the follow-up evaluation, an informative text was used. This text was similar to the previous texts in terms of length (304 words and 13 sentences) and legibility (FREI value of 20). An analysis of the answers to the reading tasks according to their categorization was conducted by two independent analysts using the SOLO taxonomy and involved comparing each answer with examples of answers from each level of the scale. Quality of learning at each evaluation time point was derived by calculating the mean of the SOLO taxonomy level assigned to each of the corresponding answers. The percentage of agreement between the analysts was calculated ((agreements ÷

agreements + disagreements) × 100), and for evaluations in which a disagreement existed, it was resolved through a discussion or (if a discussion maintained the disagreement) an appeal to a third judge. The mean percentage of agreement for the 14 cases was 91% (SD=0.1%).

2.4. Intervention

The intervention consisted of participants' use of an interactive software – the PAE v.1 – whose content (in Portuguese) was developed by the first author and whose structure related to its informatics support was assigned to a programmer (J. Ramos do Ó) with whom there was extensive collaboration regarding the software design. The software's target audience is students of secondary and higher education, but it can also be used by psychologists and educators. The rationale behind the software is that the process of academic learning requires support given its intrinsic difficulties (due to a deficit of learning competencies to a substantial degree), while it also presents significant potential regarding personal development. This software's goals are the reduction and prevention of underachievement, support of students' study, improvement of learning quality, and promotion of self-awareness and knowledge of efficacious learning practices. Essentially, while avoiding a prescriptive method, the software helps its users understand their learning mode, know alternative processes and their corresponding results and modify and regulate their learning to improve its quality. The software's activities are based on the intervention techniques that have been suggested and researched within the context of approaches to learning theory, which are referred to in "1 — introduction", and on other counselling techniques. As it is composed of relatively autonomous parts, the software provides users with free and personalized "navigation".

Specifically, the PAE v.1 is composed of a presentation, five modules and a profile sheet that summarize the users' personal results, which they can access. The presentation aims to introduce the software to its users, consisting of an explanation of its previously presented rationale, goals, method, target users, the manner of use and authorship. Each of the software's five modules presents information, examples and activities to the user, allowing him or her to do the following: 1) to know different learning strategies; 2) to become aware of his or her personal learning strategies; 3) to know how different learning strategies influence learning results; 4) to learn how to modify those strategies; and 5) to learn how to regulate them. An introduction to each module's specific tasks follows.

Module 1 ("What are learning strategies?") intends to introduce users to the notion of learning strategies, succinctly tutoring them on what they consist of and how they are used. This module, therefore, uses "theory-based reflection" (e.g., Entwistle et al., 1987), which involves promoting knowledge of learning concepts based on theoretical knowledge.

Module 2 ("Characterization of my strategies") aims to promote users' awareness of their personal learning strategies through their answers to an integrated questionnaire (consisting of the scales on learning strategies referred to in the Measures and Measurement section) and the visualization and interpretation of its results based on a detailed introduction to each strategy's characteristics. The module also allows users to view video testimonies of students on the typical use of each learning strategy. This module, therefore, uses the "reflection based on

inventories" technique (Beckwith, 1991) and the "self- and socio-reflection" technique (Gibbs, 1992), which attempts to promote students' awareness of personal and alternative learning patterns.

Module 3 ("Strategies' influence on results") is based on the "theory-based reflection" technique (e.g., Entwistle et al., 1987) and allows users to experience how different learning strategies influence learning results. The module has two activities that invite users to memorize lists of words using surface and deep learning strategies, allowing users to comparatively verify the efficacy of each.

Module 4 ("How to modify learning strategies") starts with an optional activity in which users apply and consolidate (through feedback) concepts acquired in previous modules, and it involves users' classification of testimonies on the use of different learning strategies. The module then allows users to learn how to modify their personal strategies through personalized counselling on the direction in which to modify those strategies (based on the results of the questionnaire completed in module 2). This counselling is based on the notion that the use of deep and achieving strategies tends to maximize the probability of achievement and better quality of learning, which is contrary to the use of a surface approach that tends to minimize it. Based on the notion that the deep strategy ("D") tends to be more advantageous than the surface strategy ("S") with which it relates by opposition (i.e., the use of "D" tends to reduce the use of "S"), the software considers the diverse patterns of these strategies' results, associating them with differential counselling and attempting to encourage the maintenance or increase of "D" (acknowledging its effect on "S") as much as possible, thus being as least intrusive as possible (avoiding the encouragement to reduce "S").

This counselling is provided by the software based on the following algorithm.

1. "S" scale result is higher than "D" scale result and:

1.1. High "S" (i.e., equal to or higher than 50% of the scale) and:

1.1.1. Sufficient "D" (i.e., equal to or higher than 40%) and the small difference between "S" and "D" (i.e., less than 25% of the scale) – maintain "D"

1.1.2. Sufficient "D" (i.e., more than 40%) and large difference between "S" and "D" (i.e., equal or higher than 25% of the scale) – attempt to moderately reduce "S" or increase "D" or combine both of these alternatives by attempting to moderately reduce "S" and increase "D"

1.1.3. Very insufficient "D" (i.e., equal to or less than 20% of the scale) – in a first phase, attempt to maximize "S" (attempting to apply it in an efficient and organized way until gaining confidence to be able to attempt "D") – in a second phase (when feeling more confident) attempt to increase "D"

1.1.4. Insufficient "D" (i.e., equal to or less than 40% of the scale) – increase "D"

1.2. Low "S" (i.e., less than 50% of the scale) and:

1.2.1. Very insufficient "D" (i.e., equal to or less than 20% of the scale) – increase "D" significantly

1.2.2. Insufficient "D" (i.e., equal to or less than "S" but higher than 20% of the scale) – increase "D"

2. "D" scale result is equal to or higher than "S" scale result and:

2.1. Sufficient "D" (i.e., equal to or higher than 40% of the scale) – maintain "D"

2.3. Insufficient "D" (i.e., less than 40% of the scale but equal to or higher than 20% of the scale) – increase "D"

2.4. Very insufficient "D" (i.e., less than 20% of the scale) – increase "D" significantly

3. In parallel, the counselling regarding the achieving strategy ("A") only consider the results for this strategy considering its independence relative to the other two strategies:

3.1. Sufficient "A" (i.e., equal to or higher than 40% of the scale) – maintain "A"

3.3. Insufficient "A" (i.e., less than 40% of the scale but equal to or higher than 20% of the scale) – increase "A"

3.4. Very insufficient "A" (i.e., less than 20% of the scale) – increase "A" significantly

After the counselling, module 4 proceeds with introducing and providing examples on how to plan modifications of strategies based on the phases of the self-regulation process, as conceptualized by Bandura (1986) (i.e., self-observation; self-evaluation; self-determination of consequences): decisions on a) which strategies to modify (increase, reduce, maintain); b) which learning tasks implement those modifications; c) what to modify exactly; d) how to register implemented changes; e) how to react to the eventual success of those changes; e) how to react to the eventual failure of those changes; f) whom to inform about the plan and its results. Module 4 concludes by inviting the user to rehearse a plan to change strategies based on the self-instruction process, as suggested by Meichenbaum (1977) (i.e., self-orientation of action based on an internal self-dialogue), and the empty chair technique suggested by Perls (1969) (i.e., exploration of different personal dimensions by alternating seats between two chairs facing each other).

Finally, module 5 ("How to regulate learning strategies") allows users to learn how to regulate learning strategies, considering that each of them can be more or less efficacious as a function of the different learning task. The module involves introducing and providing examples of self-regulated learning competency, as conceptualized in the Self-Regulated Learning (SRL) perspective (e.g., Boekaerts, 1997; Boekaerts & Corno, 2005; Pintrich, 2000; Zimmerman, 2000, 2002; Zimmerman & Moylan, 2009). This competency is therefore introduced in terms of a three-phase sequence that involves operations specific to each phase: 1) a planning phase, including (a) the definition of the task, b) the definition of interest in the task, c) the definition of the task's demand and goal, and d) planning resources and strategies; 2) a monitoring phase, including (e) monitoring the efficacy of implemented strategies, f) monitoring goal attainment,

and g) decisions on how to continue the task; and 3) an evaluation of the learning phase, including h) evaluation of goal attainment, i) evaluation of strategies' value, and j) a decision on how to react to the learning result, such as moving forward to another learning task or retroactively rectifying a previous phase to attain goals. Module 5 concludes by involving users in the activity of self-regulated learning competency rehearsal that is also inspired by self-instruction, as suggested by Meichenbaum (1977).

On a "profile sheet" that the users can access, a summary of their personal results is saved containing the output of the questionnaire, personalized counselling and self-regulation phases.

The PAE v.1 was presented to each participant on a computer during three individual sessions (1st session: presentation and modules 1, 2 and 3; 2nd session: module 4; 3rd session: module 5). Each session took about 60 minutes, and the use of the software was monitored by performance observation (ease of use, difficulties, comments, and questions, among others) to provide support for any technical difficulties and ensure the achievement of all of the software's tasks (based on a checklist).

2.5. Data Analysis

To compare the experimental and control groups' use of the surface strategy, deep strategy and achievement strategy before the intervention, a U Mann-Whitney test was applied, which revealed that there were no significant differences between these groups in the first place. Thus, as the null hypothesis could not be rejected, the control and experimental groups were considered equivalent.

To test H1, H2 and H3, which predicted that the intervention would induce changes in learning strategies and quality of learning, and considering the dimension of the sample, the Friedman's 2-way ANOVA by ranks nonparametric test with 3 related samples was applied. All variables were assessed at three-time points: before the intervention (pretest), after the intervention (posttest) and at follow-up. This statistical test was applied to the data from both groups to evaluate changes in users' learning strategies, for which it was possible to constitute the experimental and control groups. Wilcoxon's signed rank test was performed for post-hoc analysis. An evaluation of the difference between the experimental and the control group regarding each of their learning strategy after the intervention was done through a U Mann-Whitney test.

In addition, to test H4, which predicted that the intervention induced individual variability in changes within the sample, the efficacy of the intervention was verified for each individual case (in the experimental group), compared to the measurements of individual dependent variables before and after the intervention (analysis of instances of equal measures, increase and decrease independent variables between evaluation time points).

3. Results

First, considering the general results regarding learning strategies (H1), as shown in Table 1, it was found that the use of the surface strategy in the experimental group was significantly different at the three evaluation time points (χ^2F (2)=10.53, p=.005). As expected, the use of the surface strategy decreased significantly (p<.01) from pretest (Mdn=3.21) to posttest (Mdn=3.00). It was also found that the use of the deep strategy in the experimental group significantly differed at the three evaluation time points (χ^2F (2)=8.76, p=.013), and as expected, the use of the deep strategy increased significantly (p<.05) from pretest (Mdn=3.94) to posttest (Mdn=4.13). The use of the achieving strategy in the experimental group also significantly differed at the three evaluation time points (χ^2F (2)=8.28, p=.016), but it was not significantly higher at posttest (Mdn=4.21) than pretest (Mdn=3.71). Regarding the control group the use of the surface strategy also significantly differed (χ^2F (2)=7.37, p=.03) at the three-time points. The use of the surface strategy at pretest (Mdn=3.00) decreased significantly (p<.05) at posttest (Mdn=2.50), which was also the case in the experimental group. In contrast, there were no differences in the use of the deep strategy by the control group at the three-time points (χ^2F (2)=1.57, p=.93): Mdn=3.69 at pretest and Mdn=3.94 at posttest. The use of the achieving strategy also did not change significantly in the control group (χ^2F (2)=1.12, p=.57): Mdn=3.57 at pretest and Mdn=3.79 at posttest.

Nevertheless, there were no significant differences between the experimental and control group at posttest in any of the learning strategies.

The general results from the experimental group regarding the quality of the learning product across the three evaluation time points (H2) (Mdn=4.25 at pretest; Mdn=4.00 at posttest; Mdn=4.00 at follow-up) indicated that the differences found at these three time points were not statistically significant (χ^2F (2)=1.44, p=.487). There were also no significant differences between the experimental and control group at posttest.

Considering the general results regarding the maintenance of intervention-induced changes (H3) (Table 1), pairwise comparisons to identify significant differences revealed the following for the experimental group: the use of the surface strategy was not significantly different between follow-up (Mdn=2.79) and posttest (Mdn=3.00), and it was significantly lower (p<.01) at follow-up (Mdn=2.79) than at pretest (Mdn=3.21); the use of the deep strategy at follow-up (Mdn=4.19) was not significantly different than at posttest (Mdn=4.13) and also not significantly different than at pretest (Mdn=3.94); additionally, the use of the achieving strategy was not significantly different at follow-up (Mdn=4.57) than at posttest (Mdn=4.21) but was significantly higher (p<.05) at follow-up (Mdn=4.57) than at pretest (Mdn=3.71). In addition, the quality of the learning product of the experimental group (Table 2) was not significantly higher at follow-up (Mdn=4.25) than at pretest (Mdn=4.04).

Finally, considering the individual variability of intervention-induced changes within the sample (H4) as stated, the results of each case receiving the intervention were compared and contrasted with the dependent variable's values before and after the intervention according to a multiple case experiment methodology. In addition, for the cases in which improvement

occurred, the pre-intervention results were compared with the follow-up results. Regarding the surface strategy, comparing each case's results before and after the intervention, it was verified (Table 2) that the surface strategy decreased in 11 cases and increased in 3 cases. In comparing the pre-intervention results with the follow-up results, for the cases in which the surface strategy was decreased with the intervention, it was observed (Table 2) that the reduction was maintained in all of them.

Concerning the deep strategy, in comparing the results for each case before and after the intervention, it was confirmed (Table 2) that the deep strategy increased with the intervention in 7 cases, remained unchanged in 6 cases and decreased in 1 case. In comparing the pre-intervention results and the follow-up results in cases in which the deep strategy increased, it was observed (Table 2) that in 5 of these cases, the increase was maintained at follow-up, and in 2 cases, it reverted to the pre-intervention level.

Regarding the achieving strategy, in addressing each case's results before and after the intervention, it was observed (Table 2) that the achieving strategy increased with the intervention in 7 cases, decreased in 5 cases and did not change in 2 cases. In comparing the pre-intervention results to the follow-up results in cases in which the achieving strategy increased, it was detected (Table 2) that the increase was maintained in all of these cases.

In comparing each case's quality of learning before and after the intervention, we observed (Table 3) the following: quality of learning did not change after the intervention in 6 cases; it slightly increased after the intervention in 5 cases, and it slightly decreased after the intervention in 3 cases. In comparing the mean results before the intervention and at follow-up, for cases in which quality of learning increased, we detected (Table 3) that this increase was maintained in 3 cases and slightly decreased in 2 cases.

Table 1

Learning strategies of experimental (E) and control (C) group (median of each strategy measured by the corresponding subscale)

Group	Surface Strategy			Deep Strategy			Achieving Strategy		
	Before Intervention	After Intervention	Follow-up	Before Intervention	After Intervention	Follow-up	Before Intervention	After Intervention	Follow-up
E	3.21	3.00**	2.79**	3.94	4.13*	4.19	3.71	4.21	4.57*
C	3.00	2.50*	-	3.69	3.79	-	3.56	3.63	-

* significantly different (p<0.05) from before intervention
** significantly different (p<0.01) from before intervention

Table 2
Learning strategies of each case in experimental group (mean of each strategy measured by the corresponding sub-scale)

Cases	Surface Strategy			Deep Strategy			Achieving Strategy		
	Before Intervention	After Intervention	Follow-up	Before Intervention	After Intervention	Follow-up	Before Intervention	After Intervention	Follow-up
1	2.71	1.86<	2.29<	4.25	4.25=	4.25	2.71	3.29>	4.71>
2	3.71	2.57<	2.43<	3.75	3.75=	4.25	3.57	4.57>	4.57>
3	2.29	2.43>	2.71	3.25	3.50>	3.38>	4.43	4.14<	4.71
4	3.29	3.14<	3.00<	3.75	4.13>	3.75=	2.86	3.29>	3.00>
5	3.43	3.57>	2.86<	4.13	4.13=	4.50	3.43	3.29<	3.00
6	3.14	3.00<	3.00	3.75	3.75=	3.88	3.00	3.00=	3.29
7	3.00	2.71<	2.29	4.13	4.63>	4.13=	3.29	4.29>	4.29>
8	2.86	3.00>	3.00	4.50	4.38<	4.25	4.43	4.29<	4.86
9	2.43	2.29<	2.14<	4.25	4.25=	4.50	3.86	3.71<	4.57
10	4.14	3.29<	3.14<	3.25	3.75>	4.00>	5.00	5.00=	5.00
11	4.00	3.29<	3.29<	4.63	4.75>	4.88>	4.00	4.29>	4.14>
12	3.43	3.14<	2.43<	3.75	4.13>	4.00>	4.86	4.71<	5.00
13	2.86	2.29<	2.29<	4.75	5.00>	5.00>	3.71	4.14>	4.29>
14	4.43	3.57<	4.00<	2.88	2.88=	2.38	3.71	4.57>	4.57>

= equal to before intervention
> higher than before intervention
< lower than before intervention

Table 3
Quality of learning of each case in experimental grou
(mean in 5-point SOLO taxonomy)

Cases	Before Intervention	After Intervention	Follow-up
1	4.2	4.0<	4.5
2	3.7	3.8>	4.0>
3	3.7	3.7=	2.5
4	3.7	3.7=	3.5
5	4.0	4.2>	5.0>
6	3.8	3.8=	5.0
7	4.7	4.0<	5.0
8	4.0	4.0=	5.0
9	4.7	4.8>	4.0<
10	4.0	3.2<	3.0
11	4.3	4.3=	5.0
12	3.7	4.3>	4.0>
13	4.2	4.7>	4.0<
14	4.0	4.0=	5.0

= equal to before the intervention
> higher than before the intervention
< lower than before the intervention

4. Discussion

The group's results on learning strategies partly confirm H1, which predicted that the use of the PAE v.1 would lead to a general reduction of surface learning strategy and a general increase of deep and achieving learning strategies. The results confirm H1 regarding the deep approach to learning, which significantly increased with the intervention in the experimental group but not in the control group. Nevertheless, the results do not confirm H1 regarding the surface and the achieving strategies: the surface strategy decreased significantly with the intervention in the experimental group and the control group (although this reduction was more

significant in the experimental group); the achieving strategy increased, but not significantly, with the intervention in the experimental group. These results support the claim regarding the modifiability of approaches to learning (e.g., Biggs & Rihn, 1984) and the possibility of a computer-assisted intervention on approaches to learning (Bailey, Catchpole & Smart, 1997; McCune, 1999; Somonides & Swanell, 1995; Tait & Entwistle, 1996). The results also suggest that the intervention was successful at increasing the deep learning strategy, supporting the idea that the use of the PAE v.1 might contribute to promoting a learning strategy through comprehension, but it might be generally ineffective at increasing the achieving strategy and reducing the surface strategy. This might mean that the participants were prompted by their use of the PAE v.1 to increase their deep strategy while they were not as significantly incentivized by their environment. In line with previous studies (e.g., Bran, 2014; Gibbs, 1992), an alternative explanation is that participants' awareness and self-regulation more easily act as factors of deep learning than achieving learning, which might be more dependent on the students' values and their surface learning, which might be more dependent on their learning context. During their first year of university, psychology students are exposed to basic learning in this discipline (including the psychology of learning), which might be sufficient to reduce their surface learning (due to the impossibility of rote memorization of this large quantity of information) but not yet sufficient to increase their deep strategy (because this initial stage emphasizes critical thinking comparatively less).

Despite these promising results, the general results on the quality of learning do not confirm H2, which predicted that the use of PAE v.1 would lead to a general increase of quality of learning (i.e., increase of structural complexity in learning products), indicating a tendency of the intervention to have a neutral effect on this variable. This might be due to the use of an overly condensed intervention in a reduced number of sessions, which might not have provided the necessary time to effectively express the deep learning strategy's possible benefits on quality of learning. The same might explain the fact that the results related to the maintenance of intervention-induced changes (i.e., increase of the deep strategy) do not confirm H3, which predicted that these changes would be maintained in a follow-up observation. This condensed intervention might be sufficient for the initiation but not stabilization of such changes.

Finally, the individual results confirm H4, which predicted individual variability of intervention-induced changes within the sample. The results on learning strategies show that in the majority of cases, the intervention led to a stable reduction of the surface strategy and that in half of the cases led to an increase of the deep and achieving strategies. This suggests a relevant positive impact of the use of the PAE v.1, although the possible parallel influence of other factors (e.g., maturation; personal history) cannot be disregarded. Moreover, there were some cases that did not conform to the referred pattern, revealing that for them, the intervention was followed by an increase of the surface strategy or maintenance or reduction of the deep and achieving strategies. This probably reveals that the intervention might have been insufficient for some individuals, reinforcing the hypothesis that the effect of this intervention, as with other kinds of interventions, still depends on the interaction between individual characteristics and the intervention proposed.

Therefore, in general group terms, the intervention illustrates its efficacy at promoting the deep learning strategy and, in some cases, at also reducing the surface strategy and increasing the achieving strategy, suggesting that the PAE v.1 is a useful resource to achieve its aims related to the study sample. Nevertheless, the fact that the intervention did not demonstrate the expected impact on a few participants' learning strategies and had no impact on participants' quality of learning suggests that this particular and intensive use of the PAE v.1 (such as the one tested her) was probably insufficient for achieving a wide range of changes in all individuals and their learning products.

Based on the results, the above interpretations must be contextualized with the small number of cases that participated in this exploratory study, which limits the ability to generalize these results, and with the self-report measures of learning strategies. We find that it is necessary to implement further a similar study with a broader sample that may be representative of the population to which the PAE v.1 is oriented, and which allow power in application of statistical analyses overriding the possible contribution of other confounding variables to a treatment effect. Moreover, such a study could include a complimentary assessment of learning strategies through direct observation.

Finally, there is a need to test a more personalized, prolonged and recurrent use of the PAE v.1 within broader temporal contexts, both in the framework of students' personal lives and in terms of the psycho-educational support that educational institutions might provide.

Authors

António M. Duarte, PhD in Psychology, is Assistant Professor and Researcher at the Faculty of Psychology of the University of Lisbon (FPUL). Has been publishing and reviewing books, chapters and articles in national and international scientific journals, belonging to several editorial staffs. Has participated in several research projects funded by the European Commission, the Portuguese Foundation for Science and Technology and the Spanish Ministry of Science and Innovation. Was a member of the Scientific Council of the FPUL and consultant of UNESCO and the Ibero-American States Organization. Is a member of several research groups carrying out teaching and research activities in the field of Educational Psychology, in parallel with that of Psychology of Art. Has been teaching at several foreign universities in the framework of the Erasmus program. Coordinates the Research Program in Conceptions of Approaches to Learning" and has been coordinating several PhD and Master theses.

Alexandra Barros, PhD in Psychology, is Assistant Professor, Researcher and Vice-Dean at the Faculty of Psychology of the University of Lisbon. Specialist in Educational Psychology and in Organizational and Human Resources Psychology, recognized by the Psychologists Professional Order. She has been publishing and reviewing chapters and articles in national and international scientific journals and participating in research projects funded by Portuguese Foundation for Science and Technology. She also coordinates PhD and Master thesis and supervises junior psychologists practice in educational contexts.

References

AK, S. (2011). The effects of computer supported problem based learning on students'approaches to learning. *Current Issues in Education, 14*(1). Retrieved 30-4-2015 from http://cie.asu.edu/ojs/index.php/cieatasu/article/view/712

Bailey, P., Catchpole, R. & Smart, J. (1997). Skills shop – A learning skills package. Plymouth: University of Plymouth.

Bandura, A. (1986). Social foundations of thought and action: A social cognitive theory. Englewood Cliffs, NJ: Prentice-Hall.

Bran, C. N. (2014). Strategies for developing a deep approach of learning in higher education. *Journal Plus Education, 11*(2), 130-140.

Beckwith, J. B. (1991). Approaches to learning, their context and relationship to assessment performance. *Higher Education, 22*, 17-30. http://dx.doi.org/10.1007/BF02351197

Biggs, J. B. (1984). Learning strategies, student motivation patterns, and subjectively perceived sucess. In J. R. Kirby (Ed.), Cognitive strategies and educational performance (pp.111-134). Orlando, F.L.: Academic Press.

Biggs, J. B. (1987). Student approaches to learning and studying. Melbourne: ACER.

Biggs, J. B. (1999). Teaching for quality learning at university. Buckingham: SRHE/Open University Press.

Biggs J. & Collis, K. (1982). Evaluating the Quality of Learning: the SOLO taxonomy. New York: Academic Press.

Biggs, J., Kember, D. & Leung D.Y.P. (2001). The revised two-factor Study Process Questionnaire: R-SPQ-2F. *British Journal of Educational Psychology, 71*, 133–149. http://dx.doi.org/10.1348/000709901158433

Biggs, J. B. & Kirby, J. R. (1983). Approaches to learning in Universities and CAEs. *Vestes, 27*(2), 3-9.

Biggs, J. B. & Rihn, B. A. (1984). The effects of intervention on deep and surface approaches to learning. In J. R. Kirby (Ed.), Cognitive strategies and educational performance (pp.279-293). Orlando: Academic Press.

Biggs, J. & Tang, C. (2007). Teaching for Quality Learning at University (3rd ed.) Buckingham: SRHE and Open University Press

Bloom B. S. (1956). Taxonomy of educational objectives, handbook I: The cognitive domain. New York: David McKay Co. Inc.

Blundell, S. (1995). Should we always be aiming to promote deep approaches to learning? An evaluation of the ISL questionnaire in practice. In G. Gibbs (Ed.), Improving student learning through assessment and evaluation (pp.257-279). Oxford: The Oxford Centre for Staff Development.

Boekaerts, M. (1997). Self-regulated learning: A new concept embraced by researchers, policy makers, educators, teachers and students. *Learning & Instruction, 7*(2), 161-186. http://dx.doi.org/10.1016/S0959-4752(96)00015-1

Boekaerts, M. & Corno, L. (2005). Self-regulation in the classroom: A perspective on assessment and intervention. Applied Psychology: An International Review, 54(2), 199-231. http://dx.doi.org/10.1111/j.1464-0597.2005.00205.x

Cano, F. (2007). Approaches to learning and study orchestrations in high school students. *European Journal of Psychology of Education, 22*(2), 131-151. http://dx.doi.org/10.1007/BF03173518

Cristhensen, L.B. (2007). Experimental methodology (10th ed.). Boston: Allyn & Bacon

Diseth, A. (2013). Personality as an indirect predictor of academic achievement via student course experience and approach to learning. *Social Behavior and Personality, 41*(8), 1297-1308. http://dx.doi.org/10.2224/sbp.2013.41.8.1297

Duarte, A. M. (2007). Conceptions of learning and approaches to learning in Portuguese students. Higher Education, 54, 781-794. http://dx.doi.org/10.1007/s10734-006-9023-7

Duarte, A. M. (2012). Modification of conceptions of and approaches to learning by metacognition and changes in the learning context. In T. Patellis (Ed.). Research Studies, Literature Reviews and Perspectives in Psychological Science (pp. 133-143). Athens: Atiner – Athens Institute for Education and Research.

Entwistle, N. J. (1988). Motivational factors in students' approaches to learning. In R. Schmeck (Ed.), Learning strategies and learning styles (pp.21-51). N.Y.: Plenum.

Entwistle, N. J., Odor, P. & Anderson, C. (1987). Anticipating the experience of higher education through computer simulation. Higher Education, 16, 337-335. http://dx.doi.org/10.1007/BF00148974

Entwistle, N. J. & Ramsden, N. (1983). Understanding student learning, London & Camberra: Croom Helm.

Entwistle, N., Tait, H., & McCune, V. (2000). Patterns of response to approaches to studying inventory across contrasting groups and contexts. European Journal of Psychology of Education, 15, 33-48. http://doi.org/cgvfh9

Entwistle, N. J. & Wilson, J.D. (1977). Degrees of exelence: the academic achievement game. London: Hodder & Stoughton.

English, L., Luckett, P. & Mladenovic, R. (2004). Changing the learning environment to promote deep learning approaches in first year accounting students. Accounting Education: An International Journal, 13(4), 461-488.

Flesch, R. (1979). How to write plain English. New York: Harpercollins.

Gibbs, G. (1992). Improving the quality of student learning: theory and practice. Bristol: TES.

Goldberg, M.W. & Salari, S. (1997). An update of WebCT (Word-Wide-Webb Course Tools) - a Tool for the creation of sophisticated web-based learning environments. Paper presented to NAUWeb'9 Flagstaff, Arizona. Dowloaded in 6-4-1999 from
http://homebrew.cs.ubc.ca/webct/papers/nauweb/full-paper.html

Gunn, C. (1995). Usability and beyond: Evaluating educational effectiveness of computer-based learning. In G. Gibbs (Ed.), Improving student learning through assessment and evaluation (pp.301-315). Oxford: The Oxford Centre for Staff Development.

Kember, D., Jamieson, Q.W. Pomfret, M & Wong, E.T. (1995). Learning approaches, study time and academic performance. Higher Education, 29, 329-43. http://dx.doi.org/10.1007/BF01384497

Kybby, M., Gunn, C., MacIntyre, R. Gow, A., Granun, G. & Whyte, J. (1995). CLASS - Couseware for learning and study skills. University of Strathclyde – Heriot-Watt University.

Kozéki, B. & Entwistle, N.J. (1987). Interaction between pupil characteristics and school ethos - a review of earlier collaborative work and a proposal for a further comparative study of Hungarian and British schools. Edinburgh: Reports of research in progress - Department of Education, University of Edinburgh

Laurillard, D. (2005). Styles and approaches in problem-solving. In F.Marton, D.Hounsell, N.Entwistle (Eds.), The experience of learning : Implications for teaching and studying in higher education (3rd Ed.) (pp. 126 – 144). Edinburgh: University of Edinburgh, Centre for Teaching, Learning and Assessment.

Liping Chen & Dhillon, J. J. (2012). Deep approaches to learning in improving reading skills: a case study from Yunnan Agricultural University. Theory & Practice In Language Studies, 2(8), 1603-1613. doi:10.4304/tpls.2.8.1603-1613

Marton, F. & Säljö, R. (1976). On qualitative differences in learning - I. Outcome and process. Brittish Journal of Educational Psychology, 46, 4-11. http://dx.doi.org/10.1111/j.2044-8279.1976.tb02980.x

McCune, V. (1998). Academic development during the first year at university. In C. Rust (Ed.), Improving student learning - Improving students as learners (pp. 354–358). Oxford: Oxford Centre for Staff Development.

McCune, V. (1999). Providing learning to learn advice via the WWW. Paper presented at the "6th. Pedactice conference". Edinburgh: University of Edinburgh.

Meichenbaum, D. (1977). Cognitive-behavior modification, an integrative approach. New York: Springer-Verlag.

Neuman, S.B. & McCormick S. (1995). Single-subject experimental research: applications for literacy. Newark: IRA.

Newman D. R., Johnson, C., Webb, B. & Cochrane C. (1998). Evaluating the quality of learning in computer supported co-operative learning. Downloaded in 23-5-1999 from http://www.qub.ac.uk/mgt/papers/jasis/jasis.html

Perls, F. (1969). In and out the garbage pail. New York: Bantam Books.

Pintrich, P. R. (2000). The Role of Goal Orientation in Self-Regulated learning. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.). Handbook of self-regulation (pp. 451-502). San Diego: Academic Press.

Platow, M. J., Mavor, K. I. & Grace, D. M. (2013). On the role of discipline-related self-concept in deep and surface approaches to learning among university students. Instructional Science, 41, 271-285. doi 10.1007/s11251-012-9227-4

Richardson, J. T. E. (2005). Students' approaches to learning and teachers' approaches to teaching in higher education, Educational Psychology, 25 (6), 673–680

Richardson, J. T. E. (2007). Variations in student learning and perceptions of academic quality. In N. Entwistle, P. Tomlinson, & J. Dockrell (Eds.), Student learning and university teaching (British Journal of Educational Psychology, Monograph Series II, No. 4) (pp. 61–71). Leicester: The British Psychological Society.

Solomonides, I. & Swanell, M. (1995). Can students learn to change their approach to study? In G. Gibbs (Ed.), Improving student learning through assessment and evaluation (pp. 225-232). Oxford: Oxford Centre for Staff Development.

Svensson, L. (1977). On qualitative differences in learning - III.Study skill and learning. Brittish Journal of Educational Psychology, 47, 233-243.

Tait, H., & Entwistle, N. (1996). Identifying students at risk through ineffective study strategies. Higher Education, 31, 97-116. http://dx.doi.org/10.1007/BF00129109

Trigwell, K. & Prosser, M. (1991). Relating approaches to study and quality of learning outcomes at the course level. British Journal of Educational Psychology, 61, 265-75. http://dx.doi.org/10.1111/j.2044-8279.1991.tb00984.x

Watkins, D. (1983). Depth of processing and the quality of learning outcomes. Instructional Science, 12, 49-58. http://dx.doi.org/10.1007/BF00120900

Wilson, S. L. (2000). Single case experimental designs. In G. M. Breakwell,S. Hammond & C. Fife-Schaw (Eds.). Research methods in psychology (pp.60-74). London: Sage

Wilson, K., & Fowler, J. (2005). Assessing the impact of learning environments on students' approaches to learning: Comparing conventional and action learning designs. Assessment & Evaluation in Higher Education, 30(1), 87–101.

Zimmerman, B. J. (2000). Attaining self-regulation: A social cognitive perspective. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), Handbook of self-regulation (pp. 13-39). San Diego: Academic Press.

Zimmerman, B. (2002). Becoming a self-regulated learner: An overview. Theory into Practice, 41(2), 64-70. http://dx.doi.org/10.1207/s15430421tip4102_2

Zimmerman, B. J. & Moylan, A. R. (2009). Self-regulation: Where metacognition and motivation intersect. In D. J. Hacker, J. Dunlosky & A. C. Graesser (Eds.), Handbook of metacognition in education (pp. 299-315). New York: Routledge.

Zou, L.-H., Li, J., Chen,W.-C., Zhong, M.-L., Wang, Z.-Y. (2014). Relationship between learning quality and learning approaches of high school students on the subject of chemistry. International Conference on Science Education 2012 Proceedings, pp. 163-173. http://dx.doi.org/10.1007/978-3-642-54365-4 14