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Are Low-Achievement Classrooms Cognitively Unbalanced?

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Abstract:

Low-achievement academic scenarios, in which a large fraction of the students fails to promote to the next academic year, are a persistent reality of many universities, particularly in the initial stages of certain specialties. In this work we explore the epistemological beliefs and metacognitive strategies of a sample of first-year university students of Electric Engineering, where the non-promoting fraction is traditionally high (greater than 30%). In this situation, where academic achievement is generally low, we find significant differences between the promoting and non-promoting groups regarding both beliefs and strategies. Our results show that promoting students believe more in knowledge as a complex entity and use more self-checking strategies than non-promoting students. Within the promoting group, the less they believe in knowledge as handed down by authority, the better Grade Point Average they earned. Furthermore, students promoting with pending subjects use less planification and self-checking as metacognitive strategies than those who promoted without pending subjects. These outcomes complement with strong correlation effects between the strategies and beliefs about the structure of knowledge and the ability to learn.

Keywords: *Epistemological beliefs, metacognitive strategies, low promotion classrooms.*

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I. INTRODUCTION

One of the most difficult problems in some current universitary contexts is that of the low academic achievement. For certain specialties, the large fraction of non-promoting students in the first academic years has become a threat to both the quantity and the quality of the emerging professionals. Research has highlighted a very broad number of variables that are linked to low academic achievement, ranging from the economic, social and cultural perspective to more individual constructs in the domain of personality and human cognition. Within the latter, a number of efforts has been made to identify measurable constructs related to learning styles that are susceptible to be changed. In this way a more complete comprehension of the learning process is increasingly built, generating a wide variety of intervention approaches. However, despite this large number of studies, there is a lack of psychological and educational research specifically focused to the rather urgent context of low-achievement classrooms, where proper theoretical guides useful for the design of intervention programs are strongly needed.

The variables related to student's representation and self-monitoring of knowledge and learning has been at the center of the debate on educational psychology for long time now, though interpreted from different perspectives (Schommer, 1990; Pintrich, 1999; Strømsø et al, 2 008; Bråten et al, 2015; Schraw & Gutierrez, 2015) Two representative examples are the students' beliefs about knowledge and learning, also called epistemological beliefs or personal epistemology (Perry, 1970; Hofer & Pintrich, 1997; Schommer, 1990), and the learning strategies of students' metacognitive control (Zimmerman, 1990; Schraw, 1998). Both of them have been encountered to correlate in many ways with the academic performance in several scenarios. In fact, a systematic effort has been devoted to determine and clarify the specific relations among these cognitive constructs and its major role in the learning process by, e.g., contrasting cultural environment (Schommer-Aikins & Easter, 2008), educational level (Cano, 2005), gender (Belenky et al, 1986), domain specificity (Hofer, 2000) and many others.

In this work we make a step forward in the comprehension of these relationships for the particular context of low-achievement academic scenarios. Significant differences in the epistemological beliefs and the metacognitive strategies are explored through self-reported instruments in a sample of first-year students of Electric Engineering at the Technical University of Havana (CUJAE). This is a very typical low-achievement scenario, where more than 30% of the first-year students fail to promote to the second year. In these contexts it is also remarkable the fact that standard variables like the Grade Point Average (GPA) are not useful to discriminate subsets, since the poor academic performance keeps individual GPAs around the lowest possible value. Thus, we use the more adequate division between promoting and non-promoting groups to look for significant differences of the cognitive variables, while correlations involving GPA are still systematically tested.

Epistemological beliefs

Since 1990, the study of the personal epistemology adopted a multidimensional perspective when it was introduced the

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idea of a system of epistemological beliefs, or beliefs about the nature of knowledge and learning (Schommer, 1990). In this new frame, personal epistemology became too complex to be captured on a single dimension, and was rather conceived as a system of multiple, more or less independent beliefs. This system included beliefs about: a) the stability of knowledge, ranging from tentative to unchanging; b) the structure of knowledge, ranging from isolated bits to integrated concepts; c) the source of knowledge, ranging from handed down by authority to gleaned from observation and reason; d) the speed of learning, ranging from quick all-or-none learning to gradual learning; and e) the control of learning, ranging from fixed at birth to live-long improvable.

Nowadays, these epistemological beliefs are known to play an important role in learning (B. Hofer & Pintrich, 1997; Schommer-Aikins, 2004; Metallidou, 2013; Sajovi et al, 2013) More specifically, a large number of studies support the idea that epistemological beliefs can predict the academic performance. It has been reported, for instance, that the less the students believe in quick learning the better Grade Point Average (GPA) they earn (Schommer, 1993). Applying the same Epistemological Questionnaire (EQ) it was found later that the less the students believe in quick-learning and fixed-ability-to-learn, the better GPA they earned (Schommer-Aikins et al, 2000). And, more recently, additional evidence has been provided on the relationship between the students' epistemological beliefs and the academic performance in a wide range of educational levels and contexts (Schommer-Aikins & Easter, 2006, 2008; Cano, 2005; Schommer-Aikins & Duell, 2013).

It is worth mentioning that in the Cuban academic context the study of epistemological beliefs is slowly becoming an interesting topic for psychological and educational research. In particular, studies have targeted the connection of personal epistemology to performance in specialized domains like Physics (Morell and Manzano, 2010) and Mathematics (Vizcaíno y Manzano, 2015; Vizcaíno et al, 2015). However, more research is needed to understand the particularities of the impact of this construct in the Cuban context and provide new evidence to the general comprehension of the role of personal epistemology in the learning process.

H1: The first hypothesis of the present work is that the epistemological beliefs differ between promoting and non-promoting groups.

Metacognitive strategies

Metacognitive strategies are referred to those actions the subject perform before, during and after the learning process in order to optimize the execution of specific learning tasks. Studies show that more effective learners use metacognitive knowledge and strategies to self-regulate their learning (Schraw & Gutierrez, 2015; Bjork et al, 2013; Ekflides, 2011). In words of Schraw and Gutierrez (2015), "students are effective self-regulators to the extent that they can accurately determine what they know and use relevant knowledge and skills to perform a task and monitor their success". The metacognitive strategies are currently understood as a component of the self-regulated learning, together with cognition and motivation (Schraw et al, 2006), and are typically studied as an independent construct (Martínez, 2007; Phakiti, 2006).

It has been reported that the metacognitive strategies are connected with students' learning conceptions (Martinez, 2007), and that have both direct and indirect effects on the learning process and on other cognitive variables (Phakiti, 2006). Indeed, many recents studies evidence this role of the metacognition (Schraw & Gutierrez, 2015; Savoji et al, 2013; Bjork et al, 2013; Ekflides, 2011). In 2016, DiFrancesca et al. found that important differences emerge when comparing low and high academic achieving students regarding metacognitive monitoring, study strategies and self-efficacy over the duration of the course (DiFrancesca et al., 2016).

In general, the effect of metacognitive strategies in learning seems to be significant, even though the reports can be controversial (Mason, 1994; Zusho & Pintrich, 2003). The process of promoting self-regulated learning need to be done carefully, paying attention to the particular characteristics of the samples, and consequently much more investigation is still needed (Dalland & Klette, 2016; Schraw & Gutierrez, 2015). Thus, there is a long way through the clarification of how this construct influence learning and how this comprehension could be useful to improve academic performance.

H2: The second hypothesis of the present work is that the use of metacognitive strategies differ between promoting and non-promoting groups.

Epistemological beliefs and metacognitive strategies

The relation between the epistemological beliefs and several aspects of metacognition and study strategies has been explored in many studies. Early works by Perry (1970) and Belenky et al. (1986) have proposed that individuals with more sophisticated epistemological beliefs (they call them relativistic) are more likely to engage in personal reflection and analysis about their understandings and use of knowledge. Individuals who believe in the complexity of knowledge are more likely to take multiple perspectives, be more flexible and think in a time consuming, reflective manner. Ryan in (1984) classified students as either highly dualistic (knowledge is right or wrong, true or false) or highly relativistic (validity of knowledge is context dependent). When students were asked what their criteria were for determining whether they had comprehended a textbook chapter, dualists reported using fact-oriented standards, such as recall of facts, whereas relativists reported using context-oriented standards, such as application of facts to new situations.

In (1992) Schommer et al. found that the belief that knowledge is structured as isolated bits is linked to poor comprehension and poor metacomprehension of complex information. In the same study the authors suggest that the study strategies may mediate the epistemological beliefs effects in test comprehension. It have also been reported the relation of several epistemological beliefs dimensions with self-efficacy, goal orientation and self-regulation strategies (Phan, 2008). In general, it is already accepted that epistemological beliefs predict comprehension, metacomprehension, and interpretation of information (Schommer-Aikins, 2004).

Recents studies focus on the relation between beliefs about the nature of knowledge and learning, and the learning strategies or metacognition from different perspectives. For instance, Trevors et al. (2016) found that self-regulated learning processes vary as a function of epistemic beliefs and contexts, while Komarraju and Nadler (2013) found significant interactions with the academic performance. More specifically, it has been showed that epistemological beliefs about the speed of learning and the ability to learn significantly predicted the reported use of cognitive as well as motivational regulation strategies (Metallidou 2013). Relationship between epistemological beliefs, self-regulated learning strategies and academic achievement have been additionally reported by Savoji et al (2013). However, it is important to understand that not all the epistemological beliefs can offer insight into students' reported use of learning strategies in different contexts (Dahl et al, 2005).

H3: The third hypothesis of the present work is the existence of meaningful relations between epistemological beliefs and metacognitive strategies in our particular context.

II. METHOD

Participants

This study was carried out in a low-achievement context. It included 119 first-year junior students, about 70% of the total first year students, from the specialty of Electric Engineering at the Technical University of Havana (CUJAE). Age range was 18-22 years (M = 19.6; St. Dev. = 1.01). Boys accounted for 77.3% of the sample, and girls for 22.7%. All individual-classroom groups (from #1 to #10) were approximately equally represented.

Materials

Epistemological beliefs were measured using the well-known Epistemological Questionnaire (EQ) designed by (Schommer, 1990). The Spanish translation and adaptation used was that made by (Malbrán et al, 2005). The questionnaire is composed of 63 statements that students rated on a 5-point Likert scale ranging from strongly disagree (1) to strongly agree (5).

The EQ requires to perform a factorial analysis to process the gathered data, in such a way that the initial 63 items are grouped into 12 subsets (Schommer, 1990). Traditionally, in Schommer's studies, a four-factor solution was obtained (Schommer et al., 1992; Schommer, 1993; Schommer & Walker, 1995). Expressed in the naive form, these four factors or epistemological beliefs dimensions were: simple knowledge (structure of knowledge), certain knowledge (stability of knowledge), fixed ability (control of learning) and quick learning (speed of learning).

Metacognitive strategies were measured using the State Metacognitive Inventory (SMI) (O'Neil & Abedi, 1996) in its Spanish translation and adaptation made by (Núñez et al., 1997). It is conformed by 20 items and students rated the statements on a 5-point Likert scale, ranging from strongly disagree (1) to strongly agree (5). The authors proposed 4 categories to analyze the student's metacognitive strategies: Awareness, Cognitive Strategy, Planning and Self-checking. Each of them is represented by 5 items in the instrument.

The variable corresponding to the academic achievement is mainly expressed by the identification of the two groups, promoting and non-promoting. In turn, the promoting group is divided in two subgroups, pending and non-pending, according to whether the promotion was achieved with or without pending matters. The value of the GPA of the promoting group will be also considered in some analysis.

Procedure

Students completed each instrument during one class session, in two different moments. Firstly we administered the EQ (30-40 minutes) in the classroom, and the SMI (20 minutes) was administered under the same conditions one week later. The sessions were conducted in the morning and ensuring that each student answered the instruments independently.

At the end of the academic year, the individual academic achievement was acquired by simple collection of scores, thus identifying the students who passed to the next academic year (promoting group) and those who didn't (non-promoting group). The fractions were respectively 61% and 39% of the sample, this values are consistent with the historical range for this specialty, and characterizes the low promotion scenario we are intended to study. For students in the promoting group a GPA was also calculated. The identified pending subgroup, within the promoting group, was about 28% of the total sample.

We analyze the data by means of several statistical techniques as exploratory factor analysis, linear correlations and T tests.

III. RESULTS

Epistemological beliefs and academic achievement

Through factor analysis, using the 12 subsets established in the EQ as initial variables, a factorial structure was generated. Using the principal components method and varimax rotation, four factors were generated with eigenvalues greater than 1 and explaining 52,8% of the variance. In Table 1 we show the higher loading subsets for each factor. The four factors obtained represent the epistemological beliefs dimensions for our sample. These are: Speed of Knowledge (naive form: Quick Learning), Structure of Knowledge (naive form: Simple Knowledge), Learning Ability (naive form: Fixed Ability) and Source of Knowledge (naive form: Knowledge handed down by Authority).

Subscale	Factor I	Factor II	Factor III	Factor IV
Knowledge is certain	.647			
Learning is quick	.599			
Learn the first time	.590			
Concentrated effort is a waste of time	.561			
Avoid integration		.802		
Avoid ambiguity		.666		
Can't learn how to learn			.697	
Success is unrelated to hard work			.661	
Ability to learn is innate			.520	
Seek single answers				.776
Depend on authority				.769
Do not criticize				.423

Factor I - Quick Learning; Factor II - Simple Knowledge,
Factor III - Fixed Ability; Factor IV - Knowledge handed down by Authority

Table 1: Higher loads for factors with eigenvalues greater than 1. subsets are constructed from the 63 items EQ.

We evaluated the contrast between students in promoting and not-promoting groups, regarding the epistemological beliefs dimensions. A significant difference in the structure of knowledge was found. This belief is more sophisticated in promoting students than in the not-promoting group ($t = -2.15$, $p < .03$). That is, students that did not pass to the next year believes more in simple knowledge, while students that passed believe more that knowledge is rather complex.

In order to precise the relation between the epistemological beliefs and the academic achievement we also conducted Pearson correlations between GPA and the belief dimensions in the promoting group. These results are shown in Table 2. A significant correlation appears in the last column, and corresponds to the belief on the source of knowledge. In this way, the less the students believe in knowledge as handed down by authority, the better GPA they earned.

	QL	SK	FA	KHA
GPA	r = -.09	r = -.13	r = .12	r = -.38**
	p = .523	*p = .357*	*p = .400*	*p = .006*

QL - Quick Learning; SK - Simple Knowledge; FA - Fixed Ability, KHA - Knowledge handed down by Authority

Table 2: Pearson coefficient r and its significance p between the GPA and belief dimensions

Metacognitive strategies and academic achievement

In order to analyze the answers to the SMI the values of the items were properly processed. A value was obtained for each of the four categories: Awareness, Planning, Cognitive Strategy and Self-checking. In Table 3 we show the means and standard deviations by categories. These categories are known to conform a one-dimensional system (O'Neil & Abedi, 1996), statement that is confirmed in our study by looking at the high values of inter-category correlations in Table 3.

Categories	Mean	St. Dev.	A	P	CS	S
Self-checking (S)	3.95	.61	.61**	.53**	.80**	1
Cognitive Strategy (CS)	3.85	.61	.55**	.60**	1	
Planning (P)	4.14	.55	.53**	1		
Awareness (A)	3.92	.61	1			

** p < .001

Table 3: Descriptive statistics for the 4 categories given by the SMI analysis. Correlations among categories are also shown.

Contrasts between the groups were also encountered regarding the metacognitive strategies. It was found that the employment of self-checking is significantly higher in the promoting group compared to the not-promoting ($t = 3.02$, $p < .003$). Moreover, the results show significant difference regarding the employment of self-checking within the promoting group, i.e. between pending and non-pending ($t = 2.61$, $p < .01$). For these two subgroups, planning employment also leads to a significant contrast ($t = 2.32$, $p < .03$). That is, students promoting with pending matters uses planning and self-checking significantly less than promoting students without pending matters.

Metacognitive strategies and epistemological beliefs

A correlation analysis was conducted relating the belief dimensions with the strategy categories, finding a number of significant Pearson values. Results are shown in Table 4. As can be seen, the less the students believes in simple knowledge, the more self-checking, planning and awareness they use in their metacognitive activity. Furthermore, the less the student believes in fixed ability to learn, the more self-checking and cognitive strategies they display.

	QL	SK	FA	KHA
S	.03	-.53*	-.32*	.1
CS	.07	-.04	-.23*	.12
P	-.19	-.35*	-.09	-.03
A	-.08	-.32*	-.07	-.02

QL: Quick Learning, SK: Simple Knowledge, FA: Fixed Ability, KHA: Knowledge handed down by Authority
S: Self-checking, CS: Cognitive Strategy, P: Planning, A: Awareness

Table 4: Pearson coefficients of correlation analysis between categories of metacognitive strategies and dimensions of epistemological beliefs, * means $p < 0.05$.

IV. DISCUSSION

With the goal of study the context of low-achievement classrooms, this work explores the academic performance in relation to epistemological beliefs and metacognitive strategies, by comparing groups with different indicators of academic achievement.

Similar to Schommer's studies (Schommer et al., 1992; Schommer, 1993; Schommer & Walker, 1995) the present study generated a four-factors structure of epistemological beliefs. Our factors are, however, slightly different from those originally reported by Schommer, namely: Quick Learning, Simple Knowledge, Fixed Ability and Certain Knowledge. Actually, we did not find significant loads indicating a factor such as Certain Knowledge, but instead we obtained a new factor, conveniently named as Knowledge handed down by Authority. These type of discrepancy are very common in the literature on the multidimensional paradigm and are a reflex of the richness of the particular contexts and social environments. Within the Developmental Model Paradigm, the believe in authority as source of knowledge has been suggested in various studies since pioneering works (Perry, 1970). In particular, we highlight a work with Mozambican high school students, using the epistemological beliefs system paradigm via the factorial analysis of the EQ, in which a factor regarding the source of knowledge was also obtained (Sitoe, 2006).

The encountered relationship between epistemological beliefs and academic performance in our study is in general agreement with the many results reported in literature (Cano, 2005; Rodríguez, 2005; Schommer, 1993). More closely to our outcomes, Savoji et al. (2013) have reported, in a sample of high school students, a clear relation among differents dimensions of epistemological beliefs and the academic achievement. In particular, they found that the believe in simple knowledge predicted the low academic performance. In our study, the two dimensions of epistemological beliefs

related to academic performance were precisely the structure of knowledge and the source of knowledge. In this way, the encountered dimension of source of knowledge appears not only as a reflection of the context, but as a meaningful factor that is strongly linked to the learning process. The structure of knowledge, on the other hand, also showed to be of particular importance for learners, as this belief was found to be more sophisticated in students from the promoting group.

The metacognitive strategies were proved to have a significant relationship with the academic performance. In particular, the greater use of self-checking in the promoting group with respect to their non-promoting counterparts indicates that this category have a strong impact in academic achievement. Our results are in agreement with those reported in recent works (Martínez, 2007; Savoji et al, 2013; DiFrancesca, 2016) and, by extending this comprehension to low-achievement scenarios, we further support the general consent on the central role of the metacognition in the learning process (Schraw & Gutierrez, 2015; Savoji et al, 2013; Bjork et al, 2013; Ekflides, 2011).

It is interesting that promoting students with no pending matters were found to use more planning and self-checking than those who still have pending matters. This fact reinforce a possible use of these categories as intervention targets or experimental focus, since its improvement could have large implications not only in the quantity but also in the quality of the promotion.

Regarding the inner interactions between metacognition and personal epistemology, the belief in simple knowledge and the belief in knowledge as handed down by authority, are again the most remarkable dimensions that relates with metacognitive strategies. In this relationship, the metacognitive counterparts are the categories of self-checking, planning and awareness. The fact that the specific beliefs and strategies that showed to be important from an academic point of view are the most likely to show significant correlations among them is an additional proof their importance. This outcome is remarkable, and is in consonance with previous reports where, for instance, the belief in simple knowledge correlates to rehearsal and organizational strategies (Dahl et al, 2005), or epistemological beliefs about the speed of learning and ability to learn significantly predicted the use of cognitive strategies (Metallidou, 2013).

The complexity revealed by our findings regarding the interconnection of metacognitive and epistemological variables can be of practical help in the design and contextualization of future intervention studies.

V. CONCLUSIONS

Metacognition and personal epistemology have been studied through quantitative variables, as well as their relations with the academic achievement, in a sample of Engineering students from a typical low-achievement context. The epistemological beliefs have shown a four-factors structure. Significant correlations were encountered between the beliefs in structure and source of knowledge and the strategies of planning and self-checking. In turn, all the four constructs were shown to be significantly connected to the academic achievement. In summary, a better academic performance was linked to better employment of planning and self-checking strategies, as well as to the belief in knowledge as a complex process, derived from reason rather than authority.

Our study succeed in framing a low-achievement scenario within a learning model centered in the subject, where students' beliefs and self-monitoring abilities plays an essential role. The increasing discovery of the particular connections among these cognitive constructs, where specific shapes may vary across contexts, contributes to both the design of particular intervention programs and the deeper theoretical comprehension of the learning process.

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