

# **THE TRANSITION TO POSTGRADUATE STUDY IN MATHEMATICS: A THINKING STYLES PERSPECTIVE**

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*In this paper we focus on the transition from undergraduate to postgraduate study in mathematics through the lens of the construct ‘thinking style’ as defined by Sternberg (1997). A cross-sectional study ( $N=54$ ) was conducted in the Department of Mathematics of a large university in Greece. The data analysis reveals some statistically significant (though far from straightforward) stylistic differences between the undergraduate mathematics students and those who follow a taught graduate mathematics degree: the undergraduates appear to have a stronger preference for details, concreteness and conformity in their thinking than the postgraduates.*

## **INTRODUCTION**

The students’ problematic transition through the various stages of studying mathematics is an issue that has attracted the interest of several mathematics educators. Students encounter various problems when the level and nature of mathematics changes (e.g., transition to algebra, Kieran, 1991) or when they move to a higher stage of education (e.g., from school to university, Alcock, 2001). Indeed, these issues have been approached from different perspectives including the affective (Daskalogianni & Simpson, 2001), the cognitive (Pinto, 1998) etc.

Although there is a wide body of research looking into the transition from school to university or into transitional issues within school and undergraduate university mathematics, the transition to postgraduate study in mathematics is less well explored. Most of the studies investigating this specific transition are focused on moving to doctoral study (e.g., Duffin & Simpson, 2002), which is particularly interesting for mathematics educators as, among other issues, it involves a dramatic change in the didactical contract (in the sense of Brousseau, 1997).

However, it seems equally important to find out more about the students that choose to follow a *taught* postgraduate degree in mathematics, which may be less influenced by extreme pedagogic changes. The requirements of entering such a degree ensure that most of these students belong to those with higher undergraduate performance. Identifying special characteristics of this population will provide us with further insight into the outcomes of the existing undergraduate education system. Moreover, since the vast majority of the research students in mathematics will have completed a taught postgraduate degree in mathematics, knowing more about the special characteristics of this population will help our understanding of the transition to doctoral study.

The aim of this study is to shed some light on this population from the perspective of cognitive styles: What are the stylistic differences and similarities between

undergraduate mathematics students and the students who choose to follow a postgraduate taught programme in mathematics?

## STYLES, STRATEGIES AND APPROACHES

We wish to contrast two different theoretical constructs within the general notion of an ‘approach to study’: *style* and *strategy*. Marton & Säljö (1976) describe an approach to study as the way people choose to react in encountering a study situation. These have been classified as ‘deep’, ‘surface’ or ‘achieving’ based on the level of learning they are thought to promote (respectively deep, surface or focused on performance, which leads to a variable level of learning; Biggs, 2001). However, there is some debate about the extent to which approaches to study can be either stable across many different tasks or task specific – that is, the distinction between style and strategy.

The construct of cognitive *style* has been widely researched in psychology (for a review, see Rayner & Riding, 1997). It can be defined as “an individual’s characteristic and consistent approach to organising and processing information” (Tennant, cited in Riding, 1997). Although there appear to be various conceptualisations of cognitive styles (for a classification, see Sternberg & Grigorenko, 1997), most of the researchers agree that cognitive style is a construct which is relatively stable over domain and time.

*Strategies*, however, are employed by the students in order to cope with a specific task (Adey, Fairbrother, Wiliam, Johnson & Jones, 1999). The main difference between style and strategy is that the style describes a general preference, whereas a strategy refers to a specific choice made and, hence, is dependent on several factors e.g. the nature and purpose of the task, time, place etc.

In this study, we have chosen to focus on cognitive styles, as we are interested in characteristics of the population that are relatively stable and not in task-specific behaviour. More specifically, we consider one manifestation of cognitive styles, namely *thinking style*.

## THEORETICAL FRAMEWORK

Thinking styles are defined as the “preferred ways of using the ability one has” (Sternberg & Grigorenko, 1997, p.700). While some mathematics educators, who examined graduate study, have concentrated more generally on cognitive styles (e.g., Duffin & Simpson, 2002), focussing more narrowly on Sternberg’s thinking styles seems to be more suitable for this study as they derive from a coherent, clearly structured theory: the notion of *mental self-government*. Sternberg (1997) draws parallels between the way that the individuals organise their thinking and the way that society is governed and identifies thirteen thinking styles, grouped in five dimensions: *function*, *forms*, *levels*, *leanings* and *scope* of mental self-government (see Table 1).

These thinking styles, although relatively stable, are considered to be largely shaped by the individual's interaction with the environment and, thus, they are subject to

Dimension	Thinking Styles
Function	<b>Legislative</b> (preference for creativity)
	<b>Executive</b> (preference for implementing rules and instructions)
	<b>Judicial</b> (preference for judging)
Forms	<b>Monarchic</b> (preference for focusing on only one goal)
	<b>Hierarchic</b> (preference for having multiple objectives sequenced according to their priority)
	<b>Oligarchic</b> (preference of having multiple equally important targets)
Levels	<b>Anarchic</b> (preference for flexibility)
	<b>Local</b> (preference for details and the concrete)
	<b>Global</b> (preference for the general and the abstract)
Leanings	<b>Liberal</b> (preference for novelty and originality)
	<b>Conservative</b> (preference for conformity)
	<b>Internal</b> (preference for working alone)
Scope	<b>External</b> (preference for working in a group)

Table 1: Dimensions of thinking styles (Sternberg, 1997).

existing knowledge). Sternberg's idea suggests that being in such an environment over the long period of undergraduate study might have some implications on the students' thinking styles. Thus, one conjecture is that the postgraduates, being that part of the population who most successfully survived university, might be more 'executive' or 'local' (Sternberg's terms for styles apparently closest to Duffin and Simpson's 'alien') than the undergraduate population as a whole.

However, Zhang and Sternberg (2001) report significant correlations between approaches to study and thinking styles and Biggs (2001) notes that although most of the undergraduates "become increasingly surface and decreasingly deep in their

medium to long term change (Sternberg, 1997). Furthermore, thinking styles can be measured by an instrument that has shown its validity and reliability in various studies and countries: the Sternberg-Wagner Thinking Styles Inventory (TSI<sup>1</sup>; Sternberg, 1997).

We argue that there are two competing views about the influence of undergraduate study on the thinking styles of graduate students. Duffin and Simpson (2002) looked into the transition to doctoral study in mathematics from a cognitive styles perspective. They suggest that, among the styles they identified, the existing undergraduate educational university system, with the rapid delivery of new material, might favour students who have an *alien* style (preference for absorbing new information without any particular short-term search for links with

<sup>1</sup> Though the TSI dates back to 1992, Sternberg (personal communication, June 10, 2004) suggested using the version of the TSI included in his 1997 book.

orientation to learning [...] students with aspirations for graduate study do not show this pattern in their chosen area of study" (*ibid*, p. 91). Bearing in mind the differences between approaches and style, it can be hypothesised that a similar phenomenon might occur with the differences in thinking style. Thus, a second conjecture is that the postgraduates might be more legislative, liberal or judicial than the undergraduate population as a whole, since these styles were found to be correlated to a deep approach to study (e.g., Zhang & Sternberg, 2001).

## **METHODOLOGY**

For this study, we used the Sternberg-Wagner Thinking Styles Inventory (TSI; Sternberg, 1997). This is a self-report, paper-and-pencil test, consisting of 104 seven-scale Likert type items (eight for each style). Each participant's preference for a style is labelled (six labels ranging from 'very low' to 'very high') according to the norms developed by Sternberg's research, which varies according to the participant's gender and education (collegiate and non-collegiate). As a norm referenced test, TSI does raise some cross-cultural validity and reliability issues, since there appears not to be a published norm for Greek university students. However, the cross-cultural validity of the TSI has been generally demonstrated by previous studies (e.g., Zhang, 1999).

TSI was independently translated and back translated from English to Greek by three individuals. The translated TSI ('t-TSI') was piloted and further refined before it was administered. Note that, in this study, we decided not to examine the scope thinking styles dimension (internal-external), as we were not interested in the students' thinking preference, as far as working alone or with others is concerned. All the participants were asked for their written consent and were subsequently informed about their thinking styles profile if they requested it.

It was decided that the participants' scores would be labelled both according to Sternberg's norm ('Sternberg's labels') and according to a norm ('adjusted labels') produced by the data of this population following Sternberg's process<sup>2</sup>. This provides us with two 'lenses': a wide-angled lens which allows us to see the participants against a nominal 'general population' and a tighter lens which allows us to see differences within sub-populations of mathematics students.

## **THE PARTICIPANTS OF THIS STUDY**

This study was conducted in a large Greek university. Overall 54 students participated (Table 2) divided in two equal groups of undergraduate and postgraduate students. The undergraduate group ('BSc') is more heterogeneous consisting of students of various year groups, with varying interests in mathematics (the Greek educational system produces a large number of students entering a mathematics department without this being either their first or second choice).

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<sup>2</sup> The Kolmogorov-Smirnov test statistically supports the idea of using the adjusted labels by demonstrating the normality of the data from this sample.

	BSc	MSc	Total
Age	Mean	22.09	24.96
	Median	21	25
	St. Dev.	2.55	1.8
Male	11	15	26
Female	16	12	28
Total	27	27	54

Table 2: The participants of this study.

On the other hand, the postgraduates group ('MSc') is more ability, age and interest homogeneous: they all have an above average grade for their BSc Mathematics (mean 68.87%, median 68.40%, st. dev. 0.473). In order to minimise the pedagogical effect of the taught graduate programme, all postgraduate students were in the first semester of their two-year MSc.

## THE UNDERGRADUATE-POSTGRADUATE CONTRAST

In this experiment, the t-TSI was found to be both internally consistent<sup>3</sup> and the interscale Spearman correlation matrix shows that, in general, this use of the instrument corresponds to the theory<sup>4</sup>. The construct validity of the t-TSI was examined<sup>5</sup> and accorded well with previous studies e.g., Zhang & Sternberg (2001). Overall, the t-TSI shows good cross-cultural validity and reliability.

Recall that, since the aim of this study is to explore the stylistic differences and similarities between the undergraduate and postgraduate students of mathematics, we were able to look at the data through two lenses – the general population norm and the intra-population norm.

Comparing against Sternberg's norms, the Mann-Whitney test, conducted for all the 11 measured thinking styles, revealed statistically significant differences in only one area: the conservative thinking style ( $z = -3.215$ ,  $p < .001$ ), where there is a very significant difference. A closer look into the frequencies of the conservative labels shows that the vast majority of the undergraduates (70.37%) have a 'very high' preference for a conservative style of thinking, but so do a modal number of postgraduates (Figure 1a).

However, with the adjusted labelling process, we are able to describe how the participant's score compares to the scores of the other participants, which is at the

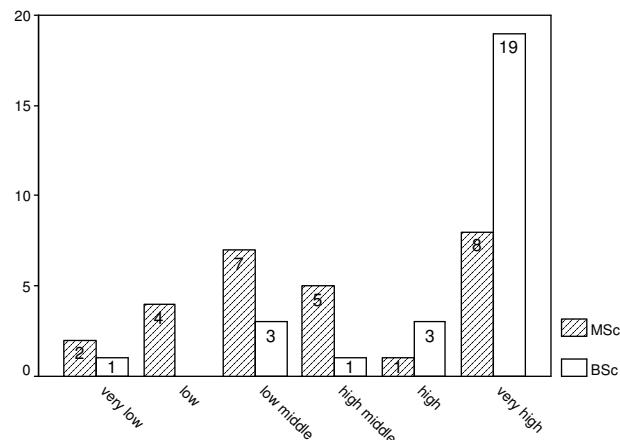


Figure 1a: Sternberg's 'Conservative' Labels.

<sup>3</sup> The alpha coefficients for 8 of the 11 measured thinking styles are above 0.7, which suggests the internal reliability of a test (Muijs, 2004). The three styles that were measured below 0.7 (but over 0.62) were also found to be relatively less consistent in previous studies (e.g., Zhang & Sternberg, 2001).

<sup>4</sup> For example, Sternberg's conservative and liberal were negatively correlated (Spearman's rho = -.309, p = .023).

<sup>5</sup> A principal component factor analysis led to a three factor solution with eigen-values greater than one (accounted for the 61% of variance). The first factor is related to creative and independent thinking (liberal, legislative, anarchic and oligarchic), the second factor is linked to procedural and already tested thinking (executive, conservative, local), and the third factor is related to a methodical and critical thinking (judicial, hierarchic, monarchic and global).

crux of answering the question at the heart of this research.

A look at the adjusted label frequencies (Figure 1b) can help in examining our population in more detail. The adjusted labels enable us to ‘zoom in’ to the ‘very high’ grouping found with the Sternberg’s norm. The Mann-Whitney test was conducted for all the measured styles.

With this more tightly focussed lens, significant differences were found for the conservative style ( $z = -3.260, p < .001$ ) and for the local style ( $z = -2.204, p < .05$ ). Thus, with this view the undergraduates are still significantly more conservative than the postgraduates, but they do not accumulate in just one label, but we also notice a difference between the groups for the local style (see Figure 1c).

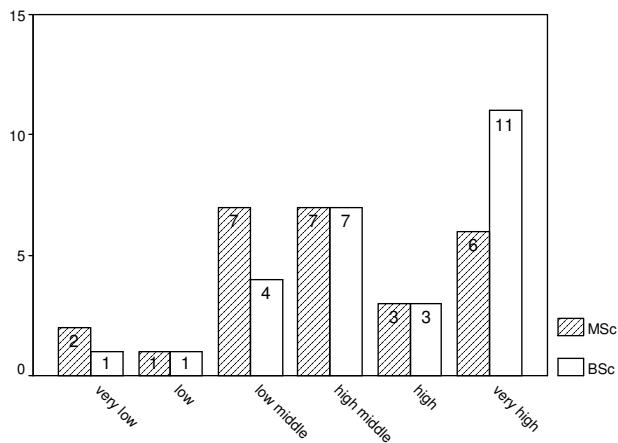


Figure 1b: Adjusted ‘Conservative’ Labels.

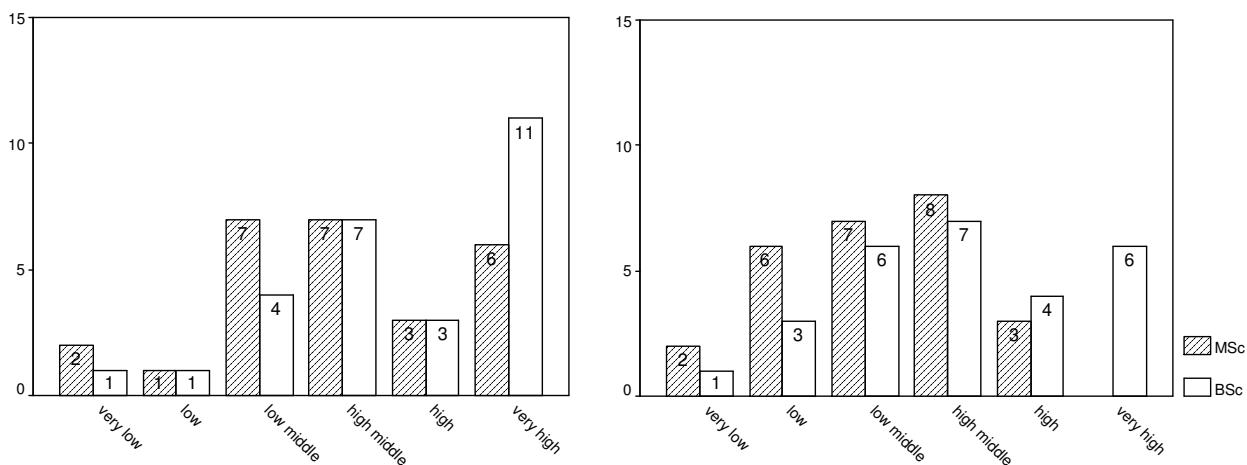


Figure 1c: Sternberg’s and Adjusted ‘Local’ Labels.

Looking at the adjusted labels for both ‘conservative’ and ‘local’ styles, we can see that we have two distributions skewed to the opposite edges of the scale, highlighting the difference between the BSc and MSc groups more clearly. Thus, the adjusted labels provide us a finer instrument, complementary to Sternberg’s labels, to look *within* our population.

## DISCUSSION

These findings indicate that the mathematics students who choose to follow a taught postgraduate degree in Greece have considerably less of a preference for conformity, detail and concreteness in their thinking than the undergraduate students (they are less ‘conservative’ and less ‘local’). Based on the rationale of Duffin and Simpson (2002), we would expect executive and local styles to be *more* prominent in the

chosen postgraduate population. On the contrary, the results of this study are closer to the conjecture derived from Biggs (2001) ‘approaches to study’ perspective.

We suggest two complementary accounts for this difference. On the one hand, it may be that students who manage to be highly successful in university mathematics do so mainly by developing the *strategies* needed for such an achievement and not by adjusting their *style*. That is, these students realised that in order to be successful in university they have to develop certain strategies which are closer to alien learning without giving up a fundamentally natural style. Thus, the sub-population who study for higher degrees may have underlying styles which focus less on the detail and memory for concrete procedures which might allow one to survive undergraduate study: that is, they are likely to be less ‘local’ in their thinking styles.

On the other hand, our two sub-populations can be seen to be quite different in other aspects of their relationship to mathematics. Because of the Greek degree system, the undergraduates, as noted, may well be studying a subject which was not their first (or even second) choice. The postgraduates, however, have made a clear subject choice.

The undergraduates are likely to have a particular goal (achievement of a degree) often for pragmatic purposes (to obtain status and a better job). The postgraduates may be more likely to have chosen their route for the sake of interest and be less clear about its pragmatic worth. The decision to leave university on completion of a degree is the majority one, while the decision to remain requires an element of non-conformity. Thus, the population of undergraduates who remain to study higher degrees are likely to be less ‘conservative’.

Overall, we conjecture that a double ‘filtering process’ (involving both the educational system and some self-regulation) might be the reason for the complexity of our findings. That is, although students who are in (and who survive) the undergraduate mathematics educational system may be skewed towards conservative and local styles, it seems that the sub-population of students that choose a taught postgraduate programme may have managed to be successful by choosing appropriate *strategies*, without actually having or developing these *styles*. Moreover, when these students choose their postgraduate direction, they make the less conservative choice, which reflects their style.

## Acknowledgements

This work was partially supported by the Greek State Scholarship Foundation.

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