Eye Movement Patterns while Solving Graph Problems Characterized by Cognitive Style: Wholistic-Analytic

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Abstract

When developing learning systems and planning curriculums, one of the most important criteria to be considered is the learner's preferred cognitive style. This thesis will focus on the wholistic-analytic styles. Certain individuals display a clear tendency toward one style and are therefore labeled wholistic or analytic, while others do not display a clear preference and are labeled intermediate (Riding & Cheema, 1991). Despite the importance of distinguishing between these styles and their connection to learning and problem solving (Santos et al., 2010), little is known about how these styles function (particularly intermediate style) or about the flexibility that characterizes them. Traditional tools used to classify preferred cognitive styles suffer from several limitations. These tools are introspective, as they are based on self-reports supplied by the learner and provide only limited information about the final outcome of the learning process (Peterson & Deary, 2006). Traditionally, "think-aloud" and written protocols have been the most useful and popular technique for understanding cognitive processes during learning (Mintzes et al., 1999). However, these methods often lacks objectivity and validity.

The current thesis will address these limitations and others by monitoring the learner's eye movements (EM). As observation in the visual field is not random (Miellet et al., 2013), tracking a participant's scan path during a given task can provide important and unique insights into how individuals process information and on the nature of the strategies that they employ. Despite the assumption that there are cognitive processes that can be identified by monitoring EM (Giuliani & Schenk, 2015; Nitzan-Tamar et al., 2016; Renshaw et al., 2003; Vila & Gomez, 2016), the relationship between EM and wholistic/analytic styles has yet to be tested. Therefore, one of the main goal of this study is to identify EM patterns that reflect wholistic/analytic process. In addition, problem-solving in general and graph-analysis in particular are impacted by the learner's preferred cognitive style and by the match/mismatch between that style and the methods required by the task. Nevertheless, minimal research has been conducted on the impact of wholistic/analytic style on mathematical performance.

The current study focuses on graph tasks in order to investigate whether optimal learning will be achieved when the style of the task (wholistic / neutral / analytic), matches/mismatches the learner' preferred style. Two additional goals are derived from this task: First, to identify patterns of EM characteristics of wholistic/analytic strategies during graph analysis. Second, to examine whether the nature of the task

influences the strategy employed when analyzing graphs, beyond the participant's preferred style.

These goals are defined using four main empirical questions: First, regarding the characterization of wholistic/analytic style: does different styles will be characterize by different EM patterns? Does the task type influence the choice of strategy or does personal preferred style dictate the strategy used? Which group (wholistic or analytic), if any, is more efficient at solving a task that matches/mismatches its preferred style? Second, regarding the characterization of wholistic/analytic style in a graphic task: do wholistic/analytic individuals adopt different graph-analysis strategies that are reflected by different patterns of EM? Does the task type influence the choice of strategy? Which group, if any, is more efficient at solving a graphical task that matches/mismatch its preferred style? Third, regarding the characterization of intermediate style: do intermediates use both strategies (wholistic and analytic) efficiently? Are intermediates more flexible at matching the strategy to the task demands than wholist and analytic learners? Fourth, regarding the characterization of intermediate style in a graphic task: do intermediates use both strategies (wholistic and analytic) efficiently while analyzing graphs? Are they more flexible, compared to the wholistic and analytic learners?

We address these questions in two studies presented in four chapters. One study included a test used to classify the learners' style as wholistic-analytic, addressing the first and third questions. The second study contained a graph test, addressing the second and fourth questions. In the first chapter, the main goal was to characterize patterns of EM that are typical of learners with tendencies towards wholistic/analytic styles. Forty students completed the E-CSA-W/A test. The main results revealed that the wholistic group was characterized by fewer fixations and transitions than the analytic group, which is interpreted as reflecting use of whole/partial strategies. In addition, wholists were shown to match the strategy to suit the nature of the task. On the other hand, analytics consistently adhered to an analytic strategy. In the second chapter, the main goal was to characterize patterns of EM that are typical of wholistic/analytic strategy during graph analyzing. Fifty-six students completed a graph test which is designated/not-designated for use of either a wholistic or analytic strategy. The results revealed that the wholistic strategy was characterized by fewer fixations on the axis and fewer transitions between the axis and the chart area,

compared to the analytic strategy. In addition, here too, wholists match their strategy to suit the nature of the task, while analytics consistently adhered to an analytic strategy. In the third chapter, the main goal was to characterize patterns of EM that are typical of intermediate learners, on a test use to classify the wholistic-analytic style. Seventy-seven students completed the E-CSA-W/A test. The results revealed that intermediate and wholist groups were more flexible in their ability to match their strategy to the task type. However, the intermediate learners performed better than the wholists, apparently because of their relative command of both strategies. Finally, in the fourth chapter, the main goal was to characterize patterns of EM that are typical of the wholistic/analytic strategy during graph analysis, as employed by the intermediate learner. Ninety-one students completed the graphical test. The results revealed that intermediate and wholist groups were more flexible in their ability to match their strategy to the task type, while again, analytics consistently adhered to an analytic strategy. These findings are consistent with the findings of the third chapter.

From the theoretical perspective, to the best of our knowledge, this is preliminary research that combines monitoring EM in an attempt to characterize cognitive style, with the impact of wholistic/analytic styles on performance in graph tasks. Furthermore, this thesis contributes to promoting our understanding of how the intermediate group processes information. From the methodological perspective, monitoring EM can significantly contribute to obtaining a deeper understanding of the differences in the behavioral measures, so that these differences can be attributed to the various strategies and the cognitive flexibility displayed by the different groups. Finally, from the practical perspective, intermediates and wholists seem to learn more efficiently and were more apt at matching their strategy to the demands of the graph tasks. Based on the findings of this study, as analytic strategy was characterized by conducting more fixations and transitions between the different AOIs, we recommend testing the influence of the style on short-term memory and cognitive load. In addition, since the global task could be solved using two strategies, we recommend examining the variability between the different groups with a more balance test. Finally, we propose to examine these findings among school students, since a significant learning of analyzing graphs, is carried out first at this period of time.