Is a Virtual Learning Environment a One-Size-Fits-All Solution? A Survey of Cognitive Styles Within a University Student Population

Russell Barton and Jonathan Foster[✉]

Information School, University of Sheffield, Regents Court,
211 Portobello Street, Sheffield S1 4DP, UK
`j.j.foster@sheffield.ac.uk`

Abstract. Over the last decade, the large-scale introduction of Virtual Learning Environments (VLEs) into higher education has been a boon to learners and teachers alike. VLEs enable students to have ready access to digital materials before, during, and after classes; and to a platform for subsequent discussion. Over a number of years a body of evidence has emerged, suggesting that learners differ in their cognitive styles in significant ways; and that the matching/mismatching of instructional design with these styles can affect both how learners interact with materials and perform tasks, and learning outcomes. A survey based on a revised version of the Study Preferences Questionnaire [4] was distributed to students at a UK university in order to identify their style. 229 students returned the questionnaire. Of the respondents, 140 students were categorized as holists, 73 as serialists, and 16 as versatile. The implications of the prevalence of holists for instructional design are discussed. In a conclusion, it is suggested that research attention be given to a structure/structuring criterion as a way of exploring the matching/mismatching hypothesis; while the development of versatile rather than optimal information processing may also be a more productive educational goal.

Keywords: Virtual learning environments · Cognitive styles · Learning styles · Holists/serialists · Matching/mismatching · Information processing

1 Introduction

Since the 2000s universities have overseen the large-scale introduction of virtual learning environments. The term Virtual Learning Environment (VLE) refers to an online space specifically designed for use by students and staff, in order to further educational goals. Typically, VLE's are seen as an extension to the classroom, providing asynchronous methods of communication that allow students to access, manage, learn and edit material in their own time [2]. More recent developments, e.g. *Adobe Connect,* have enabled users to engage in real-time interaction with and around the materials. In short, VLEs enable the asynchronous and synchronous continuation of the face-to-face instructional environment, in different places and at different times;

enabling the pursuit of educational goals outside of organized contact time between learners and teachers.

In a VLE the teacher is often not directly present, and the individual learner needs to navigate their way through the materials, without direct instruction from the teacher. Under these self-regulated learning conditions, it is considered beneficial to cater for individual learners' different cognitive styles when designing the learning materials. A cognitive style is a "person's typical or habitual mode of problem solving, thinking, perceiving and remembering" [14]. Therefore a person's learning style can be described as the typical or habitual mode of problem solving, thinking, perceiving and remembering that the individual learner displays within an educational setting. In each case research is concerned with the form of thinking, perceiving and remembering, and not the content of what is thought, perceived, and remembered.

2   Cognitive/Learning Styles

Research into cognitive styles differentiates a learner's typical or habitual mode of cognition along two basic dimensions. These dimensions are: wholist/analytic and verbalizer-imager. When addressing the wholist/analytic dimension, individual learners can be differentiated according to their capacity for adopting either a description building or a procedure building style, when approaching tasks and situations. The former involves "building a description of how elements in a topic interrelate, that is, forming an understanding of internal structure" [15], while the latter involves "building operations, that is, manipulating the underlying interrelationship between concepts in a topic" [15]. These styles are the cognitive styles as defined by the works of Pask and Scott [12, 13], in which they identified categories of individuals by their preferred approach to learning. An individual with a tendency to adopt a description building approach to tasks is known as a "holist", whereas individuals with a preferred procedure building approach are labelled "serialists". When no preference for adopting either approach is indicated, the individual is known as "versatile". Cognitive or learning styles can be viewed as a structure, as a process, or as a combination of both. When styles are viewed as a structure then attention is given to its "stability over time; as such, style is a 'given' in a training or an educational setting. Once the style in the setting is identified, the training material can be adapted or 'matched' to the individual's cognitive style" [14].

Since the 1970s a body of research has emerged around the concept of matching [12]. The concept of matching refers to how learning and teaching is considered most effective when the design of materials and instruction matches the cognitive style of the learner [3, 4, 6, 7, 9–13]. For example, in an experimental study conducted by Pask the "matched consistently performed better than the mismatched, for example, the mismatched holists needed 4 to 7 iterative repetitions in contrast to 1 to 3 for matched serialists" [11]. It was also found that learning in matched conditions was more enjoyable, quicker, and much less disruptive than in mismatched conditions. This places emphasis on the fact that in order for high quality education to occur, matching must be taken into account in the classroom. Further empirical studies support this conclusion, and highlight the fact that matching styles is greatly beneficial to education,

and to interacting with sources of information [1, 3–5, 7]. A number of studies have established the positive effects of presenting information in way that matches with a user's or learner's cognitive style. For example, Ford and Chen [7] explored the effect on learning outcomes, of instructional materials presenting information matched and mismatched with students' field-dependent/field-independent style. Under matched conditions, i.e. holists presented with instructional materials presenting information 'breadth-first' and serialists presented with instructional materials presenting information 'depth-first', students achieved a significantly higher gain score or increase in conceptual knowledge. Chen et al. [1] also explored field-dependent (FD), intermediate, and field-independent (FI) learners' perceptions of a flexible interface design to three Web directories. Among their findings, they were able to establish that in the majority of cases cognitive style predicts a preference for organizing and presenting information in a way matched with the learners' cognitive style. When the screen returned results in response to a search task, 65 % of FD users preferred the items organized and presented in subcategories first, before viewing specific results; while 71 % of FI users preferred viewing specific results first, before viewing the information organized and presented into sub-categories. Within the cultural heritage domain, Goodale et al. [8] found that users with a holist/analytic style differed systematically in how they searched, explored, and interacted with a digital library. For example, holists took longer than analytics to complete their information-seeking tasks, required more prompting, and also took longer to complete a separate path creation task. Holists also made greater use than analytics of the tag-cloud feature. Each of the findings can be interpreted in terms of the holist's initial need for an initial global overview as a way of orienting themselves in a novel environment.

3 Methods

The paper reports findings from the first part of a two-part study exploring students' cognitive styles, and their interaction with a VLE instructional design. The aim of the first part of the study was to survey the cognitive styles present in a student population. The aim of the second part of the study was to identify and explain any matching/mismatching of students' different styles via a VLE usability study. The questionnaire used is a revised version of the Study Preferences Questionnaire [4]. The questionnaire determined the tendencies of individuals to adopt description-building and procedure-building styles when approaching tasks and situations. These styles are the cognitive styles as defined by the works of Pask and Scott [12], in which they identified categories of individuals by their preferred approach to learning. An individual with a tendency to adopt a description building approach to tasks is known as a "holist", whereas individuals with a preferred procedure building approach are labelled "serialists". When no preference for adopting either approach is indicated, the individual is known as "versatile". Therefore, the questionnaire was used as a way of categorising students as either holist, serialist or versatile with regards to their cognitive style. Data on individuals' cognitive styles have been collected using many different methods. These range from lengthy and difficult to administer experiments [12, 16], to short self-assessment forms [3, 4, 14]. Since this study is focused around the theoretical framework of cognitive styles, as defined by Pask and

Scott [12], the questionnaire must be able to distinguish between description building and procedure building. Time constraints, and the associated difficulty with repeating experiments, ruled out methods used for identifying cognitive styles as developed by Pask and Scott [12] and Witkin [16]. The 'Cognitive Styles Analysis' designed by Riding and Cheema [14], is also a very well respected instrument for testing cognitive styles but combines the wholist/analytic dimension with the verbal/imagery dimension. Since the conceptual approach to matching for this study consists of the serialist/holist dimension, it would not make sense to include the verbal/imagery dimension and a Cognitive Styles Analysis was ruled out for this study. Entwistle's [3] approaches to studying inventory was also considered, since cognitive styles can be inferred from the results of assessing other deep, surface, and strategic learning strategies. Ford's [4] 'Study Preference Questionnaire', which revises Pask and Scott [12], was selected; since it directly tests for the presence of holistic and serialist tendencies among the cognitive styles of study participants.

The Study Preference Questionnaire consists of 16 questions, each containing 2 statements. The participant is required to indicate which statement they most agree with by selecting a number between 1 and 5; a selection of 1 indicates total agreement with the statement on the left and 5 indicates total agreement with the statement on the right. Only 10 of the questions are relevant for determining cognitive styles with 6 included as decoy questions. Of these 10 remaining questions, 5 are designed to calculate a value for description building tendencies, and 5 are designed to calculate a value for procedure building tendencies. For example, a question such as "If I likened the way I put an essay together to painting a wall, I tend to put a first thin coat of paint over the whole area, then put on more layers until it's done" tests a tendency for description-building; while a question such "I like to deal fairly thoroughly with the particular aspect I'm working on before going on to study" tests a tendency for procedure building.

The value returned for description building, and for procedure building, can then be used to determine the preferred cognitive style of the individual by subtracting one from the other. If the value for procedure building is subtracted from the value for description building, and the resulting number is positive, then a holistic style is present, whereas if the resulting number is negative, then a serialist style is present [4]. The questionnaire generates a spectrum of final scores between −20 and +20, with a score of 0 indicating no preferred tendency and therefore classifying the individual as versatile. A higher numerical value indicates a stronger tendency towards that style. For example, an individual with a score of +15 is much more holistic than an individual with a score of +5, whereas a score of −15 indicates much more of a serialist tendency than that of −5.

The questionnaire was distributed to all undergraduate students at a UK University of Sheffield via an email broadcasting system. The questionnaire was designed as a Google Form, which meant that responses from participants were instantly collected and stored in a password-protected responses sheet. No names were saved, making the determination of each individual's cognitive style anonymous and not personally identifiable. Analysis of the quantitative data from the questionnaire enabled the determination and identification of the presence and distribution of different cognitive styles among a sample of the university student population; while also enabling the

generation of hypotheses to be tested in a subsequent usability study conducted with volunteering students.

4 Findings

The questionnaire provided the original set of quantitative data that required analysis for this project. It was designed to calculate a student's cognitive style by generating a representative numerical score via calculations made on the student's responses. The questionnaire received responses from 229 students, generating a numerical score that represents the cognitive style present in each case. The response rate to the questionnaire was satisfying, returning a relatively large sample size, which in turn provides reliability of data [4]. Figure 1 illustrates the distribution of cognitive styles across the university students who participated, indicating that the most common score is +4. On the basis of the data returned, 140 students were categorized as holists, 73 as serialists, and 16 as versatile. Therefore, it can be asserted that 61 % of students at the university exhibit a holistic style, 32 % display a serialist style, and 7 % exhibit a versatile style. What is immediately surprising is that there are nearly twice the number of learners present in the population who display a holistic style, than those with a serialist style. While this distribution may seem surprising, Entwistle [3] provides a possible explanation for this distribution. When discussing "deep" and "surface" learning, he draws parallels between
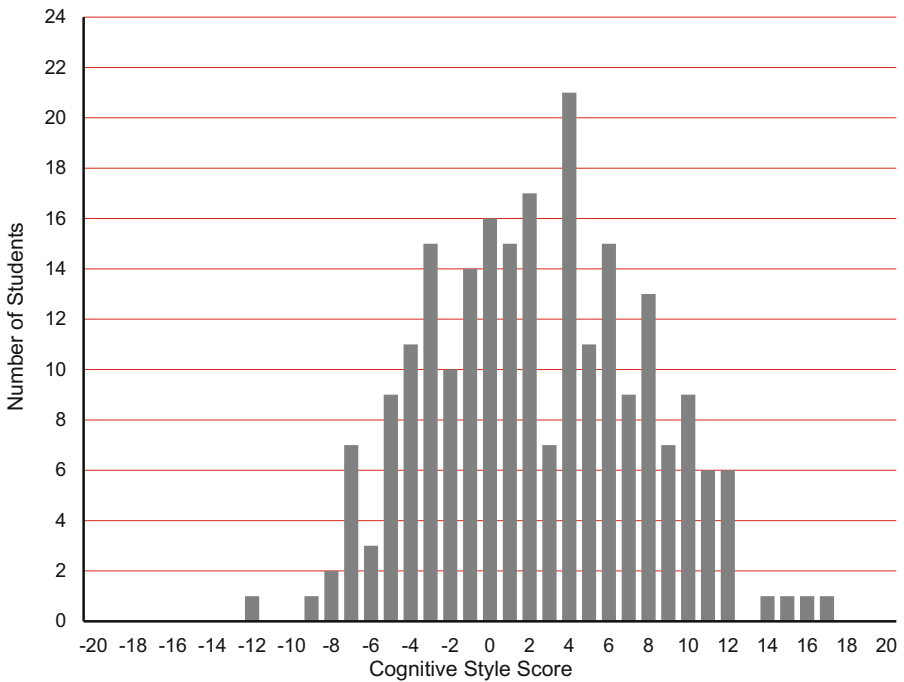

Fig. 1. Cognitive style score by student number

"deep" learners and a holistic style, and "surface" learners and a serialist style; proposing that university education requires a deeper approach to learning, and that those able to adopt a deeper approach will perform better. A university population may then naturally contain more learners with a description-building holistic learning style.

5 Discussion

The skew in distribution between students with a holist style and those with a serialist style is potentially significant, when gauging the matching/mismatching of students' cognitive styles with a VLE. In principle a VLE should enable individual learners to interact with tasks and materials in their own preferred style. In doing so an equally satisfactory learning experience is delivered to each and every learner. However, as the results from the survey highlight, differences and biases do exist. Knowing the tendencies in cognitive style that exist in a university's student population, will help to assess the relevance and significance of the impact of any bias intentionally or unintentionally designed into the VLE, and interactions with specific educational implementations of the VLE.

Is a VLE a one-size-fits-all solution? On the basis of the study conducted here, combined with those from previous studies, there are a number of possible answers. In the face-to-face educational arena Entwistle (1981) proposed that instructors should aim to accommodate all styles, and to avoid biasing instruction to any one specific style. In practice this will take a versatile teacher, who has the ability to vary his/her own style to accommodate those in his/her audience. An alternative, and more satisficing approach, based on the findings from this study, is to anticipate a broad description-building approach and an holistic style in one's university audience, and to deliver instruction appropriately. A further approach would be to adopt a holistic teaching strategy, while tailoring and personalizing where appropriate to a significant minority of serialists.

6 Conclusion and Future Research

This study identified a prevalent tendency towards an holistic style of thinking within the university student population surveyed. Clearly this has implications for the design of VLEs, and an instructional environment aimed at matching content and interaction with students preferred learning style, in a way that is educationally effective. In doing so students' levels of satisfaction with their experience can be raised.

Current information studies research, which has sought to accommodate and respond to cognitive styles in their designs, has focused on the global/analytic criterion as the factor differentiating holists and serialists' interaction with information systems. With the global aspect of the holist's style matched with breadth-first overviews, and the local or analytic aspect of the serialist's style matched with depth-first presentations of information. An alternative rationale for investigating the matching/mismatching hypothesis, that hasn't received so much attention, would be to differentiate between holists and serialists on the basis of the structure/structuring criterion. While holists

appear, at least initially, to look for a map that structures the field, and thereby aids comprehension of the ensuing topic(s) to be learnt; serialists appear to have a preference for and be adept at structuring content, at least initially, via the concatenation of discrete items of information. In other words, holists appear to some degree to be comfortable with an externally imposed structure; while serialists prefer presentation of information and facilities that enable internal structuring of the content.

An alternative path for future research is to question the very assumption that learning needs to be matched. This path could be followed in at least two ways. To place less emphasis on the relative differences of holists and serialists, and to explore the conditions under which the same learner may display different strategies in response to different learning situations, e.g. breadth-first followed by depth, or depth-first followed by breath etc. This points to a further emphasis on the development of the versatile learner; and underpinning this a different educational philosophy that points less towards optimality in cognitive information processing, and more towards versatility in information processing as a response to the needs or demands of the learning environment encountered.

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