Abstract
This paper reports a study exploring the learning styles and perceptions of a group of undergraduate and postgraduate learners in a university in the UK in relation to using the web for learning. In particular, we explore the sequential/global learning style dimension (which is concerned with the progress of understanding) in relation to three categories of web-based interaction: learner-tutor, learner-learner, and learner-information. An Index of Learning Styles is used as the tool to explore this dimension. The findings are presented with regard to the learning preferences of a group of learners towards these three categories of interaction. We conclude with a discussion of these findings in relation to Interactive Learning Systems (ILSs) design.

Introduction
Increasingly, web technology is used for learning interaction (Nielsen NetRatings, 2002; McGraw-Hill, 2002) and becoming commonplace in education institutions (Whittington and Campbell, 1998; Collis et al., 2000). However, there is still much to learn about how to make the most out of it (Hase and Ellis, 2001). As part of the instructional design process, it is important to understand the variables associated with effective matching of instructional style to learning styles (Liu and Reed, 1994). Individual differences have significant effects on learners behaviour (Riding and Rayner, 1998). These differences include gender (Ford and Miller, 1996), system experience (Holscherl and Strubel, 2000), prior knowledge and spatial ability (Mayer and Gallini, 1990), occupational experience (Durling et al., 1996) and cognitive styles (Durfresne and Turcotte, 1997; Shih and Gamon, 1999). However, individual differences make designing ILSs a complicated task as it requires accommodating a wide range of characteristics (Galitz, 2002), and for these to be interactive, certain qualities and principles need to be related to different learners’ needs. Much of the learning styles research has given little attention to influencing factors such as learner perception of
different interaction types on the learning approach they take, and how this information can inform the design of effective ILSs, which can be described as learning systems that incorporate certain design principles and qualities such as the ability to promote active thinking (Salmon, 2002), engage the learner with a variety of interactions with materials, peers, and experts (Bonk, 1999), allow for reflection and provide feedback (Laurillard, 2002), provide choices and variety of interaction patterns (Evans et al., 2002).

The following section describes a study in which we explore the sequential-global learning style dimension (concerned with the progression towards understanding) in relation to three categories of learning interaction, that is, learner-learner, learner-tutor and learner-information, which are based on voluntary choices made by learners rather than being compulsory elements of a particular course. We present our findings with regard to the learning preferences of a group of learners and conclude with a discussion of these and their value in designing more effective ILSs.

**Learning interactions**

Purposeful interaction in a specific and pre-determined way can increase the learner’s knowledge (Ritchie and Hoffman, 1997). Learning interaction can be categorised into four types (Moore, 1989; Hillman et al., 1994; Moore and Kearsley, 1996): Learner-content, learner-instructor, learner-learner, and learner-interface. This paper is concerned with three types of web-based interactions (3-WBIs): learner-information, learner-tutor, and learner-learner (Figure 1).

1. **Learner-Information (L-I):** We use “Information” instead of “Content” to indicate a wider and broader meaning to include the information that is specific to course material (content) and/or non-course material. For example this can include the learner searching the web for information relevant to their learning task or interacting with a virtual lecture. This sort of interaction forms the basis of all educational processes (Moore, 1989). The information can be presented in different forms such as text, simulation, sound, graphics, and/or videoclip. Use of multimedia can enhance the interactivity and effectiveness of such a type of interaction. Combining more than one presentation medium can enhance learning in comparison with using one alone, for example, adding picture to spoken words (Mayer, 2001; Faraday and Sutcliffe, 1997), however, this is not without challenges (Ainsworth, 1999).

2. **Learner-Tutor (L-T):** This type of interaction is considered to be highly desirable (Moore, 1989), and can take several forms, including one-to-one, many-to-one, or one-to-many. Some studies found that learners who interacted regularly with their instructor were more motivated and had better learning experiences (Garrison, 1990). It can be asynchronous using for example email and discussion board, which does not require the learner or tutor to be online at the same time. It can also be synchronous (real time) using for example chat facilities (as an online tutorial) or videoconferencing. This paper is concerned with the asynchronous side of such interaction.
3. **Learner-Learner (L-L):** According to Dewey (1996), learning can be considered as a social and interpretive activity in which learners collaboratively construct explanations and understandings of materials and phenomena within their environment. According to some studies, learners who interact on a regular basis with other learners were found to be more motivated and had better learning experiences (Garrison, 1990). Learner-Learner interaction can take several forms: asynchronously (non-real time) through using, for example, email or discussion boards, or synchronously (real time) using, for example, conferencing and chat facilities. This paper is concerned with the asynchronous side of such interaction.

These three categories of interaction can play an important role in making the learning process an interactive one, by helping to adapt instructions to better suit learners’ requirements (Jonassen, 1988), expanding interaction beyond the lecture or tutorial (Jung et al., 1998), encouraging learners to actively process information (Bower and Winzenz, 1970), providing access to learning resources (Jung and Leeme, 1999), adding flexibility to learning (Naidu, 1997; Reeves and Reeves, 1997), and allowing learners to interact synchronously and asynchronously in collaborative and distributed based environments (Harasim et al., 1995).

**Learning styles instruments**

Learning styles are considered to be “characteristic cognitive, affective, and psychological behaviours that serve as relatively stable indicators of how learners perceive, interact with, and respond to the learning environment” (Keefe, 1979, p. 4). Some authors differentiate between learning styles and learning strategies, in the sense that, learning styles have physiological basis and fairly fixed for the individual, whilst learning strategies are ways that are developed to adapt and deal with different learning tasks to make use of one’s cognitive style effectively (Riding and Rayner, 1998). There exists a wide range of literature that investigates and explores the applicability and classifi-
cations of learning styles (see, for example, Riding and Rayner, 1998; Keefe, 1979; Curry, 1983; Kolb, 1976; Kolb, 1984; Witkin et al., 1977; Honey and Mumford, 1992; Honey and Mumford, 1986; Sadler-Smith, 1996; Felder and Silverman, 1988; Felder and Soloman, 1999). Furthermore, many instruments have been developed to identify individual learning styles such as the LSI “Learning Style Inventory” (Kolb, 1985), the LSQ “Learning Style Questionnaire” (Honey and Mumford, 1986), the ASI “Approaches to Study Inventory” (Entwhistle, 1979:1981), and the ILS “Index of Learning Style” (Felder and Silverman, 1988; Felder and Soloman, 1999).

While there are advantages and disadvantages of each instrument, the measuring instrument developed by Soloman (1992) was chosen because of its relevance to the study in terms of the learning style dimension to be measured (sequential-global), ease of use (Montgomery, 1995), and the variety of information available that covers several aspects of it. However, caution has to be taken as the instrument is still being tested for validation and reliability. Also, according to Felder and Soloman (1999), while the learning style profile of a learner provides an indication of probabilities and possible tendencies, it is not an evaluation of learner’s suitability or unsuitability for a particular subject, discipline, or profession. They further add that labelling learners in this way is not only misleading but may be damaging. Felder and Soloman’s (1999) Index of Learning Styles, which is based on Felder and Silverman’s learning style model (1988), synthesises findings from several research studies in developing a learning style model. The instrument measures four learning style dimensions, through a 44-element questionnaire (11 elements to measure each dimension) that develops the preference profile of the learner. This paper is concerned with the sequential-global dimension which deals with the learner’s progress towards understanding. Table 1 includes a description of the categorisation and preferences of this dimension.

Each learning style measured by the instrument ranges between three strength levels (see Table 2) using a scoring sheet provided by the instrument.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Sequential (SEQ)</th>
<th>Global (GLO)</th>
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<tbody>
<tr>
<td>Categorization</td>
<td>Progress toward understanding: in a logical and small incremental steps</td>
<td>Progress toward understanding: in non-linear way, large jumps, holistically</td>
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<tr>
<td>Preferences</td>
<td>Tend to gain understanding/find solutions in linear manner, with steps following each other logically. Sequential learners may not fully understand the material or establish a link with other parts, but able to know a lot about specific aspects of a subject.</td>
<td>Tend to learn in large jumps, absorb material almost randomly, and may be able to solve complex problems quickly. Strongly global learners may be fuzzy about details or have serious difficulties understanding until they have the big picture.</td>
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Method
The investigation conducted is of a qualitative nature, although quantitative methods have been used in order to explore possible relationships between learners' learning styles and the three types of web-based interactions. It is based on self-reporting preferences, as such we appreciate that rather than obtaining statistically significant results we instead use these as a basis for discussion and further exploration (Yin, 1994). The study took place at a UK university involving both undergraduate and postgraduate students with different abilities and background, undertaking a degree in Information Systems. The questionnaire included the Index of Learning Style instrument along with questions to identify students' level of use and perception of the three types of interactions. It was distributed during contact time, and took approximately 20 minutes of the scheduled one-hour seminars. Out of 230 learners present, 189 completed the questionnaire, a response rate of 82%. The sample included 27% female and 73% male, which is representative of the gender difference in the Department, which is around 75% male, and 25% female. The students span a range of abilities and backgrounds, 80% identified their web/internet background as good-excellent and 20% as beginner-reasonable. In terms of population distribution undergraduate learners form the largest population (78%), while postgraduate learners form only 22%. Prior to filling the questionnaires, learners were informed of the research objectives, and that the results of the questionnaire would not be available to anyone other than the researcher. The questionnaire was anonymous in order to encourage learners to supply such details as freely and accurately as possible. Data was analysed by drawing up a profile of learning styles and making a comparison between these and the learning style preferences of these two groups. Results were obtained by adding scores using a scoring sheet provided with the instrument to determine different strength scales (mild, moderate, and strong). The data was analysed using the SPSS cross tabulation facility.

Results
Learners exhibited higher tendency towards the Sequential (68%) rather than the Global (32%) learning style (see Figure 2).

In terms of the breakdown of each style (ie, mild, moderate, and strong), 59% of the population exhibited a mild preference (balanced), 38% of which towards sequential
and 21% towards global style, while approx 41% exhibited stronger tendencies (ranging from moderate to strong) towards each style (see Figure 3).

**Frequent use of the 3-WBIs**

In terms of the 3-WBIs, Figure 4 exhibits learners’ preferences in terms of frequent use of the 3-WBIs. It shows a very close tendency between both sequential-mild (SEQ-MLD) and global-mild (GLO-MLD) styles in terms of frequent use of each type of interaction. However, it shows wider variations between other levels of the scale. For example, it shows that higher percentage of sequential-moderate (SEQ-MOD) learners use L-I and L-T interactions frequently compared with global-moderate (GLO-MOD) learners, while the reverse applies to L-L interaction. Sequential-strong (SEQ-STNG) learners scored higher percentage of frequent use of L-L interaction compared with global-strong (GLO-STNG) learners, however, the reverse applies to L-I and L-T.
Learners' perception of the 3-WBIs

Figure 5 looks at the learners' perception of the 3-WBIs in terms of their usefulness and importance for their learning. Generally, the scores are higher compared to what has been shown in Figure 4. It shows also a very close tendency between both sequential-mild (SEQ-MLD) and global-mild (GLO-MLD) styles in terms of the learners' perception of the importance of each type of interaction, with a top score of 90% for L-I, followed by L-L and L-T. However, it also shows that both Sequential-strong (SEQ-STNG) and (GLO-STNG) learners scored high (100%) in their perception of the importance of L-I interaction, followed by L-L and L-T.

Comparison between the 3-WBIs

In terms of the comparison between the 3-WBIs, Figures 4 and 5 have shown, generally, that L-I interaction scores the highest, while L-T interaction scores the lowest, and that L-L interaction lies somewhere between the two interactions.
The hypothesis that differences exist between the two styles in terms of frequency of use, finds further empirical evidence from the statistical analysis of the results (Table 3). Table 3 shows that the mean percentage for the three levels of each style (ie, mild, moderate, strong) in terms of ‘use’ is higher for Global learners than Sequential learners. Also a mean comparison using t-tests for each interaction type (ie, L-I, L-T & L-L) highlighted the significance of such differences between the two styles (p < 0.05).

On the other hand, Table 4 shows that the mean percentage for the three levels of each style (ie, mild, moderate, strong) in terms of learners’ perception of the 3-WBIs is higher for Global learners than Sequential learners in terms of L-I and L-L interactions, but lower in terms of L-T Interaction. It also shows higher mean compared with Table 3. Also a mean comparison using t-tests for each interaction type (ie, L-I, L-T & L-L) showed that differences exist between the two styles in terms of learners perception of their importance (p < 0.05).

### Discussion

The results show that sequential learners represent a higher percentage of the population. It also shows that 41% of the population (which is a significant percentage) are categorised as having strong-moderate tendencies, while 59% exhibited a more balanced style (mild). In terms of L-T Interaction, the scores are much lower than those in the category of L-I Interaction. In terms of L-L Interaction, the results show that this type of interaction scores higher than L-T Interaction, but lower than L-I Interaction. Despite that, both types of learner scored high in their perception of the importance of such type of interaction in comparison with actual use of them. In terms of L-I interaction for Sequential learners, who tend to gain understanding, find solutions in linear manner, with steps following each other logically, it is essential to include activities and...
interactive exercises which allow learners to take a linear approach through step-by-step progression of topics such as the use of structured type presentation. However, for Global learners who tend to learn in large blocks and absorb material seemingly randomly, it will be necessary to provide the learner with the big picture, and connections between the parts. For example by providing a section on the screen that provides an overview of main topics in the module, once a topic is chosen a list (overview) of subtopics is presented in the section, providing mind maps, menus etc (eg, Figure 6).

In terms of L-L and L-T interaction, providing a variety of asynchronous interactions through, for example, the use of discussion (bulletin) board for different activities such as different group assignments, discussions, brainstorming, activities and problem solving exercises can help Sequential learners to get involved in a progressive manner and be able to see the development of the argument, while also giving opportunities for Global learners to obtain a holistic view of the discussion through the linking of different discussions to subject topics that constitute the whole. WebCT ™ learning environment is an example of a learning environment that integrates different educational tools that help the learner to interact with fellow learner, tutor, and learning material (WebCT, 2003).


Figure 6: Combining the principles of structured and ill structured design (adapted from MSc course in Multimedia for eCommerce, Brunel University, UK©)
Conclusions and future work
The study has shown that learners have different perceptions of different types of web-based interactions. It demonstrates that Learner-Information interaction has the highest score in terms of frequency of use and perception of its usefulness compared with other types of interaction. The study also shows that despite the relatively low scores in frequency of use of the three interactions, learners’ perception of their usefulness and importance remains high, which suggests that there could be other influences which need investigation in order to close such gap between “actual use” and “Perception”. The results also show that the majority of learners have higher preference towards sequential (rather than global) learning style, and a significant percentage of them had moderate-strong tendency to one of the learning styles. We suggest, therefore, that the design of ILSs should take into account such variation in learning styles in relation to the three interactions investigated, taking into consideration learners’ different levels of “use” and “perception” of the 3-WBIs in order to provide a more balanced interactive learning environment for more effective learning. Some design issues have been explored in the discussion section above, however, there is no quick fix or answer to all problems, but understanding about learners learning styles can help in establishing the right balance between accommodating learning styles and developing important skills in the context of ILSs. We believe that learning styles instruments does not necessarily give absolute or definite answers to all learners’ problems in using ILSs, but they help to highlight some areas of possible significant importance to learners learning. Learning styles instruments should be used to diagnose and predict probable difficulties that might be experienced by some learners when using ILSs at early stages of the course in order to take necessary remedial action before it is too late. This in turn should lead to important gains in the acceptability and usefulness of ILSs. An awareness of the pedagogical needs of different learning styles can result in more effective ILSs. Such a carefully balanced approach not only can help learners to respond more effectively to different learning situations, but also can make the learning process more enjoyable and help in developing a more flexible and autonomous learner.

The study reported in this paper is a part of an ongoing research on ILSs design. Our future work includes investigating other learning style dimensions (such as: Active-Reflective, Sensing-Intuitive, and Visual-Verbal) in relation to the three interaction types and also investigating other individual differences such as gender, prior knowledge, special needs and language fluency in relation to learning styles.

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