USING LEARNING STYLES THEORY TO IMPROVE ON-LINE LEARNING THROUGH COMPUTER ASSISTED DIAGNOSIS

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Introduction and Context

Despite the success in a number of education and training environments of a variety of Learning Styles diagnostic tools[1,2] and particularly the success of Honey and Mumford[3], there still appears to be a scarcity of research, development and action on the application of this work to e-learning. When we compare developments around the issues of, for example, content development and pedagogy[4], authoring and packaging tools[5], virtual and managed learning environments and interoperability[6], or accessibility of learning products and services for disabled people[7], we find comparatively little research and comparatively very little application of Learning Styles thinking to the development of e-learning products, services, environments and practices.

If the research environment is somewhat sparse compared with other research developments in the e-learning arena, the application environment is surprisingly barren in the light of the supposed and potential impact of Learning Styles developments in the period from 1995 to 2001[8]. The authors of this paper have either worked with or studied for this paper the following range of products:

- VLE Vendor-created products, most notably Teknical[9]

- The product portfolio distributed through the NLN product development project[10]

- The BBC's on-line education content, most specifically the Bitesize products[11]

- Thomson Net-g's product range, and its published papers[12]

- The FD Learning product range, and its published papers[13]

- Products created and distributed through JISC programmes, most notably the 5/99 and Exchange for Learning programmes[14]

What we have found in looking at both private-sector and publicly project-funded products and programmes is an increasing emphasis on learning design, trailing behind technical and visual design by some years, but an emphasis on learning design from a producer-product perspective rather than from a user-learner perspective. There is a predictable variety in product type and quality in the many hours of product represented in the list above, but no instance of Learning-Style driven thinking providing the sort of product variation and flexibility we think possible[15].

However, when we transfer what Honey and Mumford claim application of Learning Styles can do for learning in general to e-learning in particular, we find an as yet unexplored and unexploited capability to improve the performance of technology, people and organisations. In terms of products, services, environments and practices, we will propose the following:

Products – Learning Styles-driven product design can have a significant impact on the instructional, linguistic, graphical and technical design of learning products, and specifically Learning Objects.

Services – Learning Styles thinking has the potential to impact upon the configuration of courses, programmes, diagnostic strategies, delivery methodology, support management and assessment of performance.

Environments – there is significant potential impact of Learning Styles on the configuration of the role of the VLE in learning delivery.

Practices – there is significant potential impact of Learning Styles on the interaction between participants in the learning process – from instructional designers and learning technologists to course/programme managers, technical support and management workers, to tutors and students.

Through an analysis of the work of Honey and Mumford – applied both to some specific learning content and to the general question of VLE-based e-learning course design – we intend to show that:

- There is a model to be developed of a 'Learning-Style-Driven' Learning Object, which current authoring and browsing technologies are especially well placed to deliver, and where content providers are in an excellent position to improve practice.

- There is a model of a 'Learning-Style-Friendly' course design, which practitioners and VLE managers can implement to ensure greater effectiveness of VLE-based courses.

The paper finally proposes an action-research project with teachers and learners in a specific area but encompassing the (UK) Secondary, FE and HE phases to investigate the impact of:

- The application of information about Learning Styles to Learning Object design in a number of real-life cases

- The application of Learning Styles analysis to course design for a number of learner groups working in distributed and blended learning settings

Honey and Mumford as a Model of Learning Styles

Research into how people learn has been a subject of interest for well over a century, but some of the most influential research is that of Honey and Mumford which resulted in the learning styles questionnaire of 1986. According to Peter Honey, this questionnaire is '…the most widely used diagnostic of its kind in the UK'[16]. Some FE colleges and other providers of education and training use it to identify the learning styles of their students, adapting teaching programmes and delivery accordingly. By so doing they hope to improve the learning process by addressing issues that are specific to individual learners and settings rather than generic across groups and communities.

The Honey and Mumford questionnaire emerged from their research into the ways in which students learn[17]. It was based on an analysis of Kolb's Four Stage Model of Learning[18]. Kolb's research suggested that for successful learning to take place, learners should follow a cycle to include concrete experience, reflective observation, abstract conceptualisation and active experimentation. Honey and Mumford's research pointed towards particular personality profiles preferring one or more stages of the cycle to the others. Their questionnaire is therefore based on personality models so that individual approaches can be used advantageously to enhance the learning process. They divide learners into activists, pragmatists, reflectors and theorists.

The activists enjoy novelty, challenges, activities in which they can be involved in discussing ideas or doing something practical. They dislike monotonous tasks which require checking of detail. They learn best from student-centred methods, role play, games and presentations. They learn least from didactic teaching, lectures and demonstrations. The pragmatists like to apply a practical solution to a problem, putting the theory into practice,

applying solutions and working out systems. They are life's decision makers who find it difficult to work with ambivalence. Teaching methods which appeal are practical projects, action planning and simulations. They do not enjoy reading, lectures or group discussions, especially those based on theoretical issues.

Reflectors feel that they must consider all available options. They are cautious, thoughtful people who like to listen and observe. They prefer to analyse all available information before reaching a conclusion. Therefore they prefer to learn via lectures, reading, data analysis, demonstrations, and case studies, disliking role play, improvisation and group work. Theorists prefer to work through subject material logically, analysing rationally before synthesising and evaluating. They are objective and dislike ambiguity, subjectivity and illogicality. They learn most when learning is structured and logical. They prefer observing demonstrations and listening to lectures or reading. They do not find it easy to learn through group work and role play and do not find it helpful to explore emotions.

So we have a framework in Honey and Mumford for diagnosing a learner's preferred style, and inferring from this the sort of experiences and behaviours most likely to create a learning impact. We can go from there to designing learning products, services, environments and practices that take account of the diversity of learning styles. Before we provide some models of this, we should look at one instance of e-learning material to see what would happen if we applied learning style thinking to its design and presentation.

An Example – BBC GCSE Bitesize and Learning Style-Driven Design

The example we will look at is taken from the BBC's Bitesize revision site, specifically the sections relating to composition in English for GCSE[19]. There are several reasons for identifying this example, most importantly:

Ubiquity and **access** – this product range enjoys ubiquity and freedom of access, and is popular with schools, FE colleges, learners and parents.

Coverage of composition as **both a skill and knowledge** – this example offers an opportunity to acquire both a skill and some new knowledge, and it is clear that the focus of the learning objective will influence the presentation of the matter to be learned and the style best adopted or already preferred by learners.

The **target audience** – predominantly 15-17, which matters in terms of presentational features, and the extent to which learners adopt preferred learning styles

The product's **structure** – though not a Learning Object, the product is typical of on-line learning product structures in general, with a mix of linear and hyperlink-based navigation to move to other areas.

The **presentation** of the product – for the 'composition' section, presentation is text, all on one page, which we argue is likely to appeal to the reflector/theorist group. This is important, as this group is less likely to have problems with composition for the GCSE English curriculum in the first place than other groups – their learning styles already pre-dispose them to succeed.

We can take a look first at the composition section:
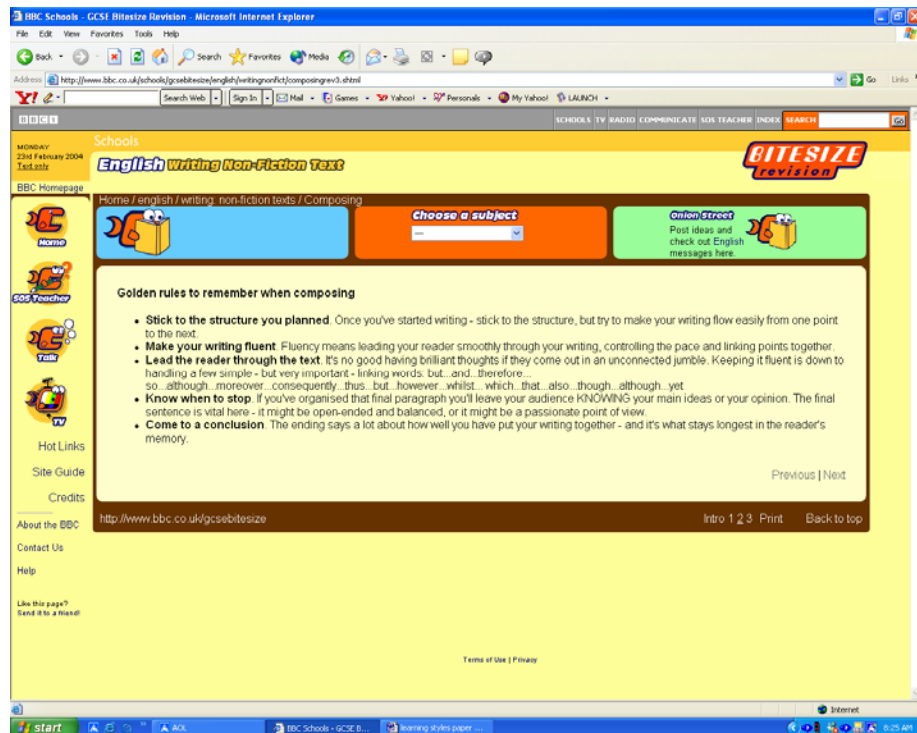
We are positing firstly here a link between preferred learning behaviour of the given style and a preferred screen-based or product based activity. We see this working as follows:

Activists – will want to do something practical, likes games and activities – will want to be active and interactive with the screen, keyboard and mouse.

Pragmatists – will want to act, and see action as linked to a real-world situation – will want to experience simulations, action, planning.

Theorists – will enjoy reading, demonstrations, data – will want to have material presented and to act upon it analytically.

Reflector – will enjoy reading, reflecting and balancing perspectives, comparing and contrasting – will be comfortable with the linear, observation based presentation that we currently have above but not perhaps with its uni-dimensional nature.

So if we are building this product with the same two learning objectives, we start by identifying these:

Objective 1 – recall and state the 'golden rules'

Objective 2 – apply the golden rules to own writing

Using what we have said about the implications of learning styles for product design, we would obviously need to depart from the product we have above and offer a range of choices to learners based on their preferences. How we call these choices into play in the delivery of a Learning Object will come later, but for now we have to say that the text-based product we have will not suit all styles, and develop it so that it might.

The best way of showing how this would work is to present it as a table, indicating where learning style preferences can be addressed through:

- Ensuring that presentation accommodates preferred style

- Ensuring that the learner engages with the application of rules

- Engaging the learner's styles by focusing on a preferred composition genre

Style	Knowledge objective	Application objective	Style-appropriate activities – linked to genre
Activist	Make the page available to the user as a jigsaw with instructions – the user manipulates the elements until they fit together to make sense. This makes the user read for meaning in order to assemble the bits.	An activity based on a short but structured piece – again a jigsaw, where the user has to assemble the whole from the pieces. This makes the user do something on the screen, and make judgments about how to perform the composition rules.	The activity is based on a newspaper advertisement or article.
Pragmatist	The user drags explanatory text onto a heading to show that they've made the link between the two – keep what is there, but make the user do something practical with it.	An assembly exercise, this time based on a structure-line for a piece of writing that links facts as they apply chronologically to the piece and to the structure of the piece itself.	The activity is based on an action plan or set of directions.

Theorist	Make it a flash movie presentation – same information as is there, but operates as a click-on demonstration.	Place a composed piece on screen, but with sentences missing that connect the elements of the piece – place the connector elements right of screen, numbered. Then match the two by typing in the number – not a drag and drop, but a matching exercise that will appeal to theorists' analytical tendencies.	The activity is based on a letter of explanation or complaint.
Reflector	Could be as is.	Present the facts and opinions behind the piece and three or four different pieces for comparison, with multi-choice questions about composition and structure.	The activity is based on a discursive essay or persuasive speech.

You will see that in this design we have sought to keep everything 'on the screen' – we have not engaged support or tutorial services external to the web-based product – in order to maintain the spirit of the learning product and its independence from human services. This makes the job more complex, but the idea is to produce a learning product that takes account of learning styles within itself.
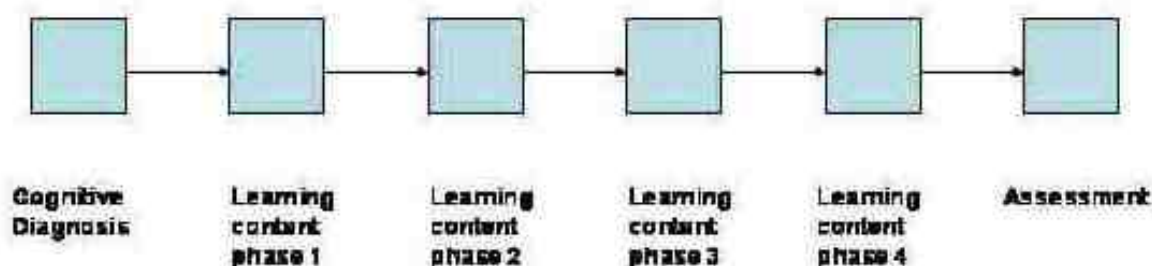
Learning Object Structure and Learning Styles

So we can see how we might develop a learning resource with Learning Styles in mind – in this section we will consider specifically how Learning Objects (LO's) look now compared with how they could look if Learning Styles theory were incorporated into LO design. We have already seen that the current state of research and development does not suggest a high level of engagement between Learning Style and LO design activity – whether we look across the research community, across the content vendors' portfolios or in detail at any one group of products. The first question is, what does this mean for the state of LO and learning product design currently?

We should say here that this paper has to take for granted a couple of things about LO's. Firstly, we are defining a Learning Object as a SCORM Level 2 LO, an aggregation of SCO's, a coherent self-contained learning experience, a content package[20]. Secondly, we are assuming that the minimum requirement for an effective LO is – Pre-assessment/Learning Content/Terminal Assessment. Unfortunately not all of the products we have studied (including the BBC product) provide even this minimum, but we will proceed with the definition, developing it as we go to include a more theoretically informed account of the internal phases of the LO.

Figure 1 shows the simplest form of acceptable learning design currently in evidence in the product ranges we have encountered. The learning design is linear, with the learner doing a pre-assessment prior to experiencing a number 'chunks' or sections of learning. At the end of the line, the learner undertakes an assessment that tells him/her whether learning has been achieved, and reports to a learning management system if that functionality is available.
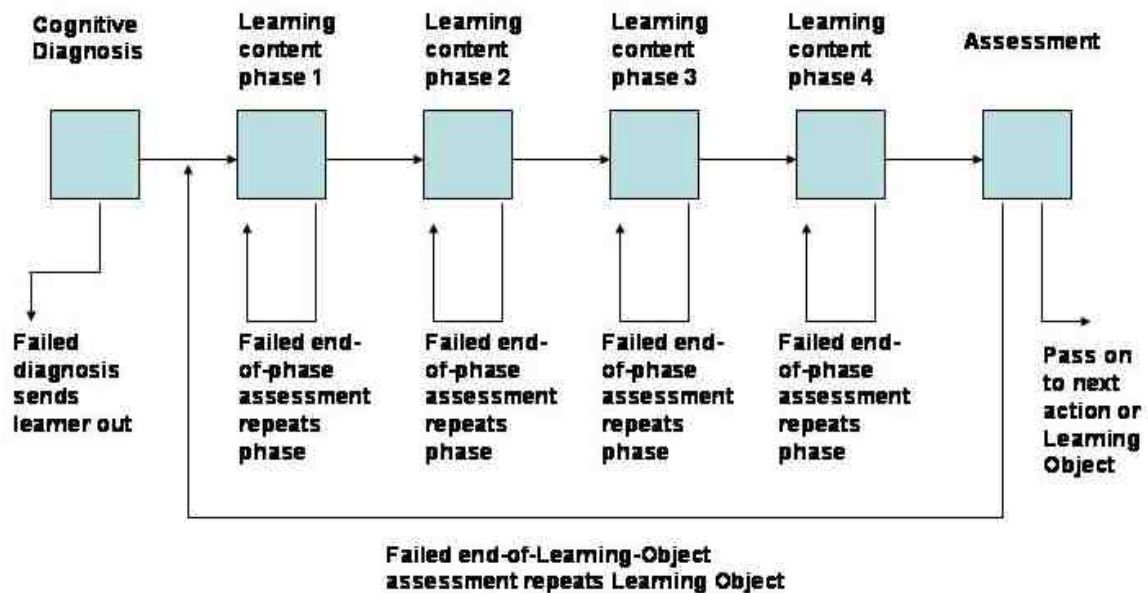
Figure 1 – Simple Linear Learning Object

| Cognitive Diagnosis | Learning content phase 1 | Learning content phase 2 | Learning content phase 3 | Learning content phase 4 | Assessment |

In this model there is no accounting for Learning Style in the way material is presented. In the products we have studied, the LO might accommodate many styles of learning in a 'shotgun' approach to media or interactivity, but it is not in itself designed to respond to the Learning Style of the learner, partly because the Learning Style cannot be 'known' to the LO.

Figure 2 shows a similar level of linearity, but this time with assessment loops built in to take account of where a learner fails to get through a phase of learning. Here no attention is explicitly paid to the learner's style in his or her performance in a phase of learning, but there are iterative gestures enabling the learner to receive content in more than one form or mode if a failure to pass through a phase makes it necessary. We have not seen many examples of this structure, but we did have some success with it in developing an Exchange for Learning product in English Literature in 2002[21].
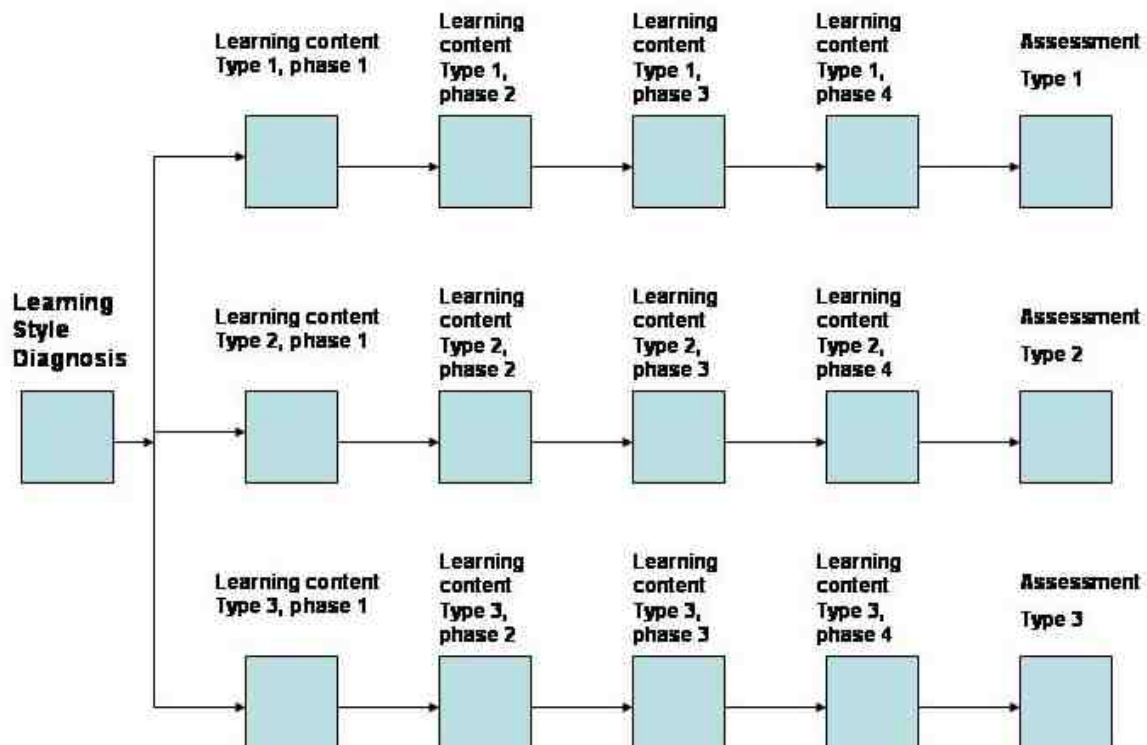
Figure 2 –Linear Learning Object with Internal Assessment Loops

Cognitive Diagnosis	Learning content phase 1	Learning content phase 2	Learning content phase 3	Learning content phase 4	Assessment

Failed diagnosis sends learner out

Failed end-of-phase assessment repeats phase

Failed end-of-phase assessment repeats phase

Failed end-of-phase assessment repeats phase

Failed end-of-phase assessment repeats phase

Pass on to next action or Learning Object

Failed end-of-Learning-Object assessment repeats Learning Object

We would argue that this model is more satisfactory, because it increases its 'strike-rate' of interactions and responds to a user failing to reach a level of learning within phases of learning in the LO. It also forces both the product designer/deliverer and the user/learner to be aware of what differentiates the phases. This could be simply a gradient of difficulty or complexity, or it could be, as it was in the Literature example referred to above, a learning loop based on a theory such as Kolb's cycle[22]. It does not take account of the user's Learning Style, but it does enable the learner to receive information or instruction a second time if the internal assessment suggests he or she needs it.

Figure 3 shows an example of an LO where Learning Styles are figured into the learning process through a diagnosis that takes place at the outset. The results of this diagnosis determine the presentation of learning content to the learner at a fairly high level – the whole of the product presented is determined by the results of the diagnosis, with no room for subtlety in between the phases of learning or in the distinction between the presentation of information, interactions and assessments.
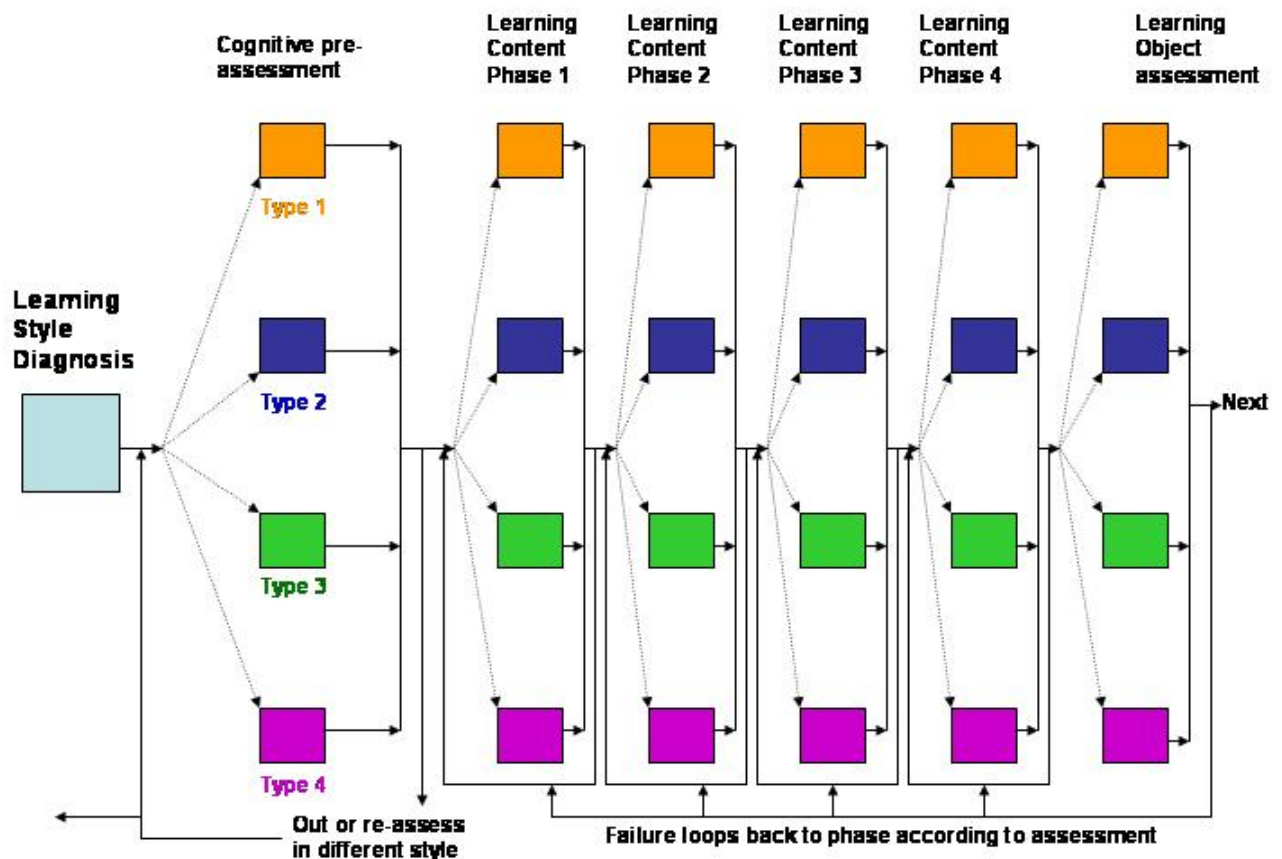
Figure 3 –Learning Style Diagnosis Determines Content Presented Throughout Learning object

	Learning content Type 1, phase 1	Learning content Type 1, phase 2	Learning content Type 1, phase 3	Learning content Type 1, phase 4	Assessment Type 1
Learning Style Diagnosis	Learning content Type 2, phase 1	Learning content Type 2, phase 2	Learning content Type 2, phase 3	Learning content Type 2, phase 4	Assessment Type 2
	Learning content Type 3, phase 1	Learning content Type 3, phase 2	Learning content Type 3, phase 3	Learning content Type 3, phase 4	Assessment Type 3

This model is taken from a product currently in delivery in a commercial environment, where detailed analysis of its efficacy is not available. What we can say is that it is not premised on Honey and Mumford but on a model akin to that developed by Bandler, Grinder and Grinder[23] – and therefore it distinguishes between modes of learning-presentation in terms of a categorization of learners as visual, auditory or kinaesthetic in predisposition instead of activist, theorist, pragmatist or reflector – early tests suggest that it enjoys high levels of learning-impact and that users register high levels of enjoyment, satisfaction and motivation.

Figure 4 shows how Learning Styles might be more fully integrated into an LO. We should say here that we have not seen any examples of this product, so we are not in a position to report on a test. What we are doing is proposing this model as the basis of the build and test we are going to carry out from autumn 2004 onwards. We are confident that the technology we have available in the development/authoring, delivery/serving and user/browsing environments is easily capable of delivering and testing this product.

Figure 4 – Learning Object Structure
Based on Learning Styles Diagnosis

Here the user's Learning Style is obviously more prominent in how the experience is delivered to the user, with the LO experience working out as follows:

1. The diagnosis of style determines which of the types the cognitive pre-assessment will come in – this becomes the 'dominant style' of the user for this LO.

2. The cognitive pre-assessment measures required knowledge using the learning style determined by the Learning Style Diagnosis – it also issues data on the dominant style and identifies a 'secondary style', so that the route though the phases can be moderated if necessary

3. If the user 'passes' the cognitive pre-assessment, they go forward to phase 1, if not they can be re-assessed using a different style or sent

out of the Learning Object with an indication of required action before returning

4. At phase 1 and subsequently the dominant style determines the presentation of learning and assessment of learning at that phase, with the secondary style offering the method of addressing the failure loop

5. The LO Assessment is issued in the dominant style, with the results providing the option to return to any one of the phases in other styles as necessary

This model is still somewhat crude, and we are aware of the need to fine tune, especially at the assessment end of the LO. What we are confident of, though, is that this model is worth testing in terms of costs and benefits, and that we should at this point state some of our expectations in this regard.

In terms of cost, it is obvious that it will be more expensive to create Learning Objects according to the model above. There will need to be a standardised group of Learning Style Diagnostic Assessments, this group including differentiation at least by level and possibly by a classification such as course or skill type. Obviously, there will be additional product build-costs. The base-level intellectual property costs will remain the same, but creating four groups of each phase will add to media and development costs. Finally, there will be additional programming costs in the outline build of the LO. This cost will decrease as more Learning Objects are built and proper templates become available, but at the outset the costs will be high.

We envisage, however, that these costs will prove worth incurring in the benefits that derive. The first is additional impact – put crudely, we are looking for a Learning Object that will accommodate and deliver to every user, where at the moment it seems likely that a small percentage of users is hit by a Learning Object of the type characterised in figures 1 and 2. Secondly, we will of course be generating additional re-usable items of media and interactivity in the build of any one LO. Providing that we get the work right at this level of granularity, there will be the prospect of re-using all items in different configurations. Finally, we expect higher levels of LO and product longevity. Currently learning product longevity can be measured in weeks and months, a situation we believe to add high levels of hidden cost.

**Application of Learning Styles to e-learning Delivery**

So far we have talked about how a product would look if Learning Styles theory were effectively engaged with the design and build process. We need now to consider how delivery of learning through current technology might look given the same gesture of inclusivity to Learning Styles. This is about how we deliver learning as people and organisations, regardless of the nature of the learning content we have at our disposal, and is therefore much more a matter of the services, environments and practices we deliver and adopt to maximise learners' chances of success in an arena that we know to be difficult[24].

We can start by looking at the usual toolkit we would employ in the delivery on an on-line or e-course. Whether we are talking about a distance learning course using the technology as an enabler, a blended solution, or a component of a traditionally delivered programme that makes use of the technology, we have in this toolkit delivered to us by our VLE's and other digital services the following as a general minimum:

- Simulations

- Discussion Groups

- Notice-boards

- Learning Objects

- On-line content, including Multimedia and Interactions

- Tasks/Research

- Off-line tasks

- Focused discussion groups

This list is not exhaustive, but gives us a sense of the variety of content, communication, interaction and management functions that the technology can give us. The question is, how do we match the functionality with the diversity of learning styles we expect of students and user groups? Let's start with a simple diagram that matches the Honey and Mumford Learning Styles with the functions we have listed:

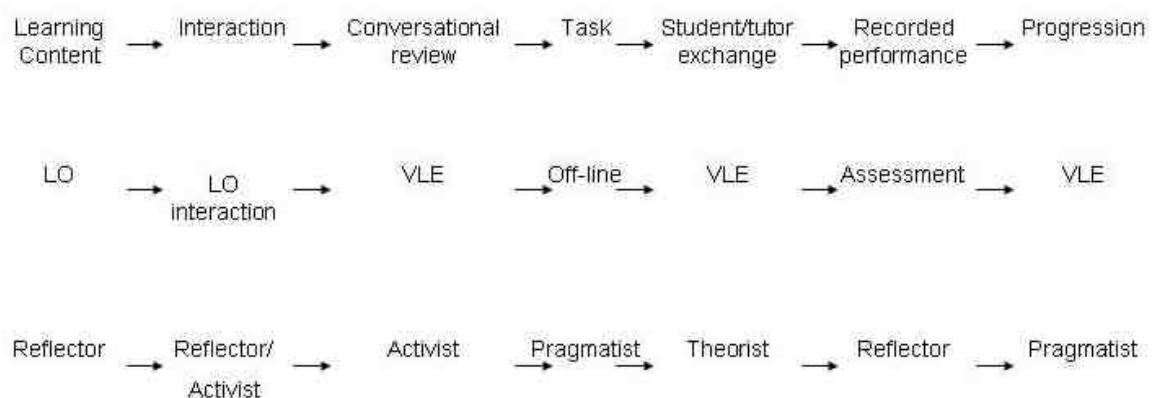**Figure 5 – The Learning Styles/e-learning Programme Quadrants**
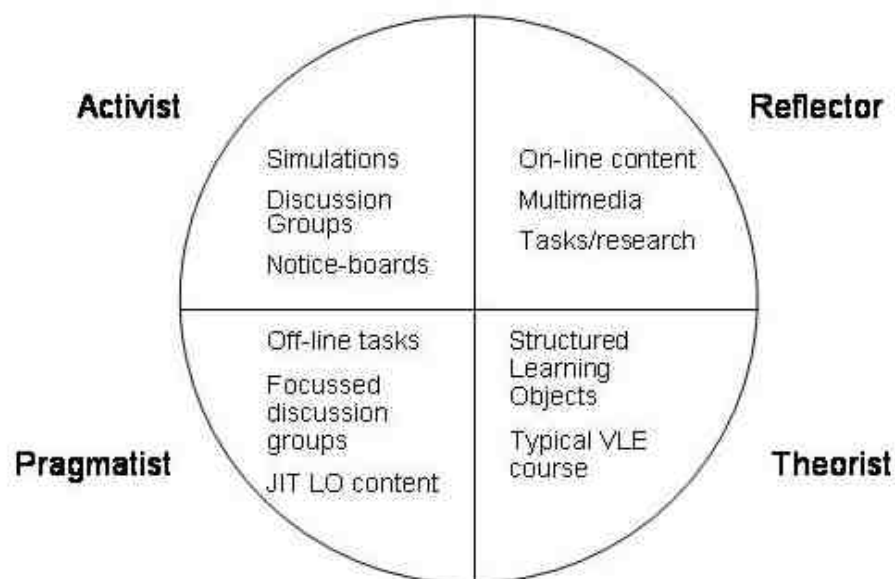
This should be self-explanatory – certain styles map to certain activities and features because those activities accommodate the preferences of the style.

This, like our Learning-Styles driven LO, is crude, but it does alert us to the prospect of the technology being managed to take better account of Learning Styles. We have in our study for this paper looked at or been directly involved in on-line programmes delivered by over 20 public and private sector UK FE, HE and training organisations, including single-college or HEI projects in north and south Wales, multi-partner projects working on a regional and national level in all of the home nations, multiple instances of on-line ECDL programmes, a variety of Ufi programmes, pan-national or multi-national programmes offered by corporates, and broadcaster-based multi-platform projects using the web as a feature in the mix. Accommodation of learners' preferred styles is not the norm in this group in the way that, for example, ensuring the adequacy of technological equipment, the level of technical skills, satisfaction of cognitive pre-entry requirements or even motivation levels, are considered essential.

So with this mapping model, we can consider how we might configure an e-learning course or programme – let us say delivered through a VLE – to take account of both the mix of learning styles in our groups and the desire we would have to develop a range of styles in each individual learner. The first model – shown in Figure 6 – takes a mixed set of styles and shows how the course might be configured to enable all styles of learning to be addressed, accommodated and developed. In this model we should note that we are taking a very different view from that adopted above when we discussed learning products. In LO development, we are proposing that the LO be able to respond to Learning Style and deliver to the dominant and secondary styles it finds in the learner. That is because the LO contains no space for human intervention and natural evolutionary flexibility – it's still a bit of software, however smart we try to make it. In the delivery of a learning course or programme, we are assuming human intervention and engagement, and therefore wider scope for adaptation.

Figure 6 – A Mixed Profile of Services in an e-learning Programme

In short, what has happened here is that the learning programme has been set up to accommodate a range of styles – the learning content will appeal to the reflectors, with an interaction following it that appeals to activists as well, shading into a VLE based conversation and so on. Providing all of this activity along the learning continuum is in pursuit of a single learning objective, it has a greater scope and chance to reach a wider range of learners in a group, ensuring that by the time assessment takes place all learners have learned in the style that is appropriate to their needs. Of course, if the learning products used in the process were of the type described as Learning Styles driven earlier, there would be an even higher chance of success.

If we decided not to attempt to cover all Learning Styles in a single run through a learning objective or task, however, we might want to build processes that accommodated dominant pairs of styles or even specific styles. The research on this area is inconsistent and inconclusive, with Jones et al[25] claiming that Learning Styles are age and cognitive-domain independent and Davison et al[26] claiming a degree of match between curriculum areas and learning styles. These cases are not easy to reconcile, largely because they work with slightly differing accounts of Learning Style in the first place. What we argue here is that Honey and Mumford is especially useful if we are trying to predict and account for learning styles in colleges and universities, partly because we can predict some degree of match between curriculum framework, qualification type, cognitive domain and learning style. Whether this is the case or not, it is now possible and affordable to run Learning Style assessments across groups of learners at a number of points in their programmes to ensure that our delivery fits their requirements as well as to ensure that they are aware of and are developing their own range of learning capabilities.

However we do this in practice, we can now add two further figures to show how we can mix the delivery profiles according to dominant and secondary styles in a group. Figures 7 and 8 show how we might configure a learning programme to accommodate learners who could be predicted to be, or who showed up in Learning Style diagnosis as, either reflector/theorist or pragmatist/activist.

Figure 7 – A Mixed Profile of Services in an e-learning Programme – Reflector and Theorist

Learning Content	→	LO interaction	→	Assessment	→	Task	→	Student/tutor exchange	→	Recorded performance	→	Store
LO	→	interaction	→	LO assessment	→	Research	→	VLE	→	Assessment	→	VLE score
Reflector	→	Reflector/ Activist	→	Theorist	→	Reflector	→	Theorist	→	Reflector	→	Reflector
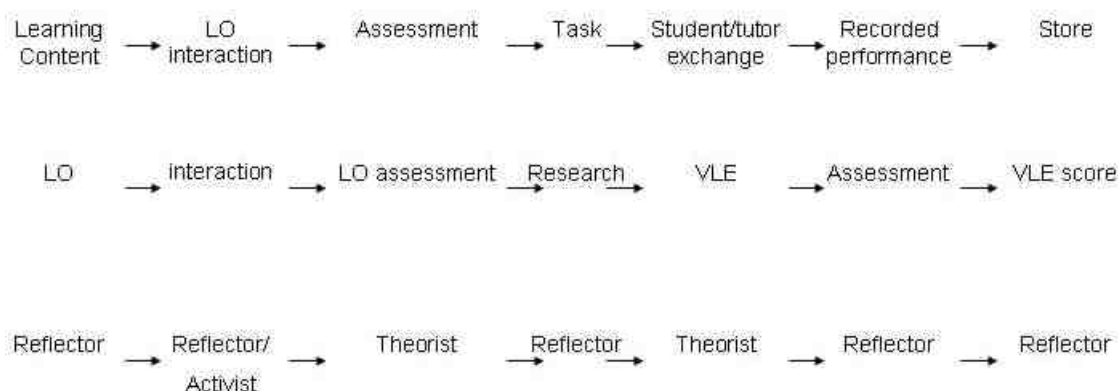
Figure 8 – A Mixed Profile of Services in an e-learning Programme – Pragmatist and Activist

Web discovery task → LO interaction → Conversational review → Task → Peer exchange → Group exercise → Progression

LO prompts → interaction → VLE → Off-line → VLE discussion → VLE → VLE

Pragmatist → Reflector/Activist → Activist → Pragmatist → Activist → Activist → Pragmatist
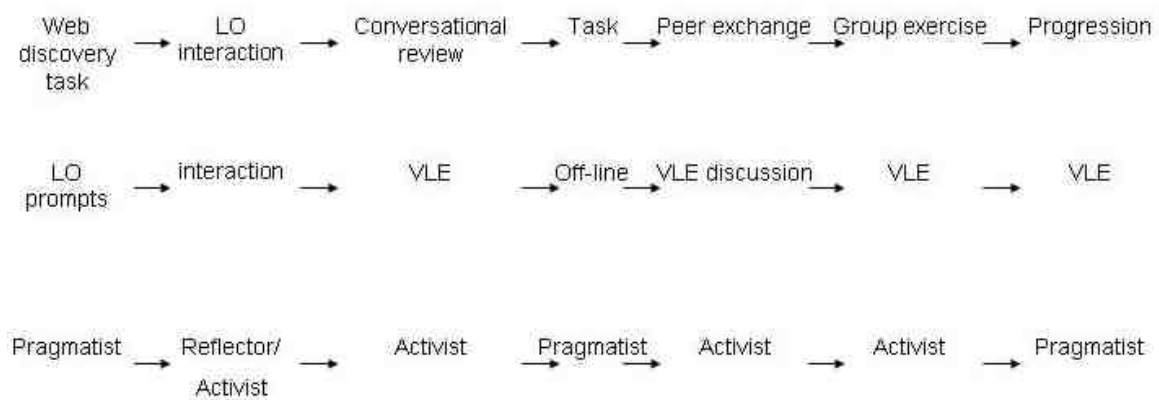
So we have in this variety of configuration of elements the beginnings of the accommodation of Learning Styles in programme design. As with the LO design, the models are somewhat crude and need working out in detail and testing, but we would argue that the models offer the same approach – take Learning Styles into account at the outset – and that this approach is yet to be tested for its effectiveness.

When we looked at the LO issues, we concluded with an outline of costs and benefits. We do not consider this to be necessary here – the costs of designing a learning programme do not seem to us to alter significantly if you take into account our model or not. Where there will be an impact is in the area of provider-skills. We would argue that the whole matrix of providers – from technical staff through support workers to tutors and managers – will need to be more conversant with the orientation of the learner in order to deliver this model effectively. This we consider to be a good thing, possibly even a goal in itself.

Conclusions

In conclusion, then, we have looked in general at Honey and Mumford's model, applied it to an example of existing learning resources, offered a model LO structure from it and sought to apply it to the delivery of a learning programme using the technology. We can close this account with some general conclusions from this work, and suggest a way forward for improving on it.

Firstly, we would argue that LO research and development has been technical-producer led, with Learning Design really being product design and the emphasis being on defining the parameters of the LO to ensure product-interoperability standards. We would argue that it is time to move on from this. LO's have not to date been about selecting content-presentation and

assessment in modes suitable for different styles – but this is exactly what we promote in training teachers and lecturers to be effective in the classroom.

Secondly, when we consider cost and benefit in the design and build of an LO, we must accept that our model represents a higher cost, but also argue that it will be worth it. It appears to us that the higher cost is only a part of the argument – we can imagine content producers looking at the contests between Learning Styles frameworks and seeing sands that shift too quickly to support the building of a specification. We – perhaps because we are activists – think that there is enough security in the link we have made between Learning Styles and Learning Object structure for some tests to be developed. We also note that, whatever the cost, the model we propose represents a chance to improve significantly the educational effectiveness, viability and longevity of Learning Objects made available to the community.

Thirdly, it is clear that the Learning Object situation has an analogy in the world of VLE and other technology supported learning programme delivery. As practitioners we have been led by what the technology can do (or what technologists and vendors tell us it can do) rather than what we would want to do in the design of excellent programmes. Again we argue that it is time to apply the principles we would apply to 'live' or classroom-based programmes to technology-enabled programmes to ensure that learners with all styles get the best quality learning experiences from our efforts and investments.

So we need to go back to what we said in the introduction about next steps and further research. We will from autumn 2004 be undertaking an action-research project with teachers and learners in a specific area but encompassing the (UK) Secondary, FE and HE phases to investigate the impact of:

- The application of information about Learning Styles to Learning Object design in a number of real-life cases

- The application of Learning Styles analysis to course delivery design for a number of learner groups working in both distributed and blended learning settings

We expect to be able to report on this work in the summer and autumn of 2005.

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