Building Personalised Functions into Dynamic Content Packaging to Support Individual Learners

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Abstract

Learning Management Systems (LMS) are now being widely used in education. Their main function is to systematically manage and deliver learning materials. There is a need for LMS that can deliver personalised material suited to the learner's learning requirements and their learning style. A method and associated techniques have been developed that addresses these issues by use of a multi-dimensional model, and can be potentially built in the LMS as an integral component. This method is demonstrated by its application to an online course in C programming.

Keywords: Personalised learning, e-Learning support, learning styles in e-learning systems, personalisation design algorithms

1. Introduction

The rapid evolution of information technology has created opportunities to offer various tools to support learners engaging and managing their learning. One technology which has been considered as the potential to maximise investment return by leveraging people, systems, and process is the Learning Management System (LMS). The LMS is capable of creating, fostering, delivering, and facilitating learning at anytime and anywhere. However, the LMS has limited functions on learning content management which constraints effective learning support. The current LMSs have rationalised their development by using reusable learning objects (RLO) that enables instructional designers to configure the learning materials that target the knowledge gap, allows learners getting the instruction when they need and desire to learn, and makes possible that the system is able to personalise learning materials based on learners' learning behaviour (Brockbank, 2002). These capabilities have opened up opportunities for learners to require just-in-time personalised learning materials, engage their learning with preferred styles, and enjoy their learning experience to achieve personal learning goals.

These new requirements from learners for using the LMS raise challenging issues in an instructional design for courseware. Firstly, how the individual learner's learning requirements can be captured before the learning material is packaged; secondly, how the appropriate learning objects can be selected based on the learner's requirements; finally, how the participation of learning on the materials can be monitored and the required support can be provided by the system. We address these issues by developing a method for personalised instructional design (MPID). The main aim of MPID is to build a software component through which the individual learners can express their learning requirements, e.g., a way they prefer a presentation for the learning materials, a selection of the learning contents, and sequencing of the learning objects. This method has been experimented in one of our existing courses in the University.

In this paper, we, first of all, review various ways (learning styles) in which learners learn. An analysis on the learning styles will result in a construction of MPID architecture. The techniques in MPID will be described and followed by discussions on the current work and future research.

2. Related work

The analysis of learners' requirements is vital for identifying what they want and what they expect from a learning environment. It is also essential for the instructional designer to know learners' characteristics in order to build a system that maps learners' preferences.

2.1 Learning as knowledge construction process

It is recognised in the education that learning is a process of knowledge construction. Constructivist claims that learners construct their own reality, or at least interpret it based upon their perceptions or experiences. Constructivists emphasise the role of the learners, who take on increasing responsibility for their learning (Honebein *et al*., 1993).

Semiotics, as a discipline of the study of sign, has a strong influence on the way we understand the world which we live in and the way we conduct our work. The subjects of study of semiotics are all kind of signs. A sign is "something which stands for something else in some respect or capacity" (Peirce 1931-35). Signs can be a verbal language, pictures, literature, motion pictures, theatre, body language, and more. Semiotics has a strong relationship with understanding, as Peirce describes in the key notion: semiosis. Semiosis is a process that involves an agent using a sign in understanding or interpreting something (Stamper *et al*., 2000; Liu 2000). Understanding is a subjective process where the prior knowledge affects the interpretation of a given sign, and vice versa. It is difficult to assume for all agents involved to derive the same association between a given object and a sign, as it involves issues such as meaning, cognition, behaviour, culture and social context.

Adopting semiotics and constructivist paradigm would have a tremendous impact on designing of an e-learning environment. An e-learning environment should facilitate learners to interpret the multiple perspectives of domain context, guide learners to conduct and manage their personalised learning activities, and encourage collaborative and cooperative learning for critical thinking and problem-solving (Liu and Sun, 2002; Sun *et al*., 2003).

These two paradigms raise some challenging issues in e-learning on how individual learners can be facilitated and supported their learning effectively. We believe that an understanding of individual learners' learning behaviour and styles is one of the fundamental functions which should be built in learning management systems.

2. 2 Learning styles

Individual learners tend to apply different ways (styles) of learning with which they can achieve effective results. Therefore, an effective learning requires an instructional design on learning materials to take learning styles into account.

A learning style is simply a preference for the method by which an individual learns and remembers what he or she learned. Everybody has a preferred learning style. Knowing and understanding our learning style helps us to learn more effectively.

Most learning theories focus on the individual learner and recognise that different learners learn in ways that are unique to them. Students have different learning styles and these can affect how they learn. This is the reason why instructional designers need to understand the importance of learning style and should adapt their instructional strategies to match the various learning styles of learners.

O'Connor (1999) suggests that research of learning styles enable instructional designers to identify clusters of people with similar patterns for perceiving and interpreting situations and to adjust learning environments making them more efficient and successful places for each cluster.

There are many different classifications of learning style found in the literature. The most common and widely used is the perceptual style which refers to the preferred sensory modality for receiving information. Generally, learners prefer either a Visual, Aural (Auditory), or kinaesthetic (Tactile) mode, although most use a combination of perceptual strategies for selecting and processing information. For the designer, what matters is to provide key concepts in more than one modality, with learner control built in.

From the way learners respond to information, they can be categorized as Activists, Reflectors, Sensing and Intuitive learners. These terms are explained below. In addition, learners can be grouped into two other categories depending on the way they prefer to access information or learning materials in this case. These are sequential and global learners.

These six important categories of learning styles (Activists, Reflectors, Sensing, Intuitive, sequential and global learners) together with the above perceptual styles have been identified and studied for the purpose of this project. They will be referred in the rest of the dissertation as Dimension 1 (*Activists, Reflectors, Sensing,* and *Intuitive learners*); Dimension 2 (*sequential* and *global learners*) and Dimension 3 (*Visual, Auditory,* and *Tactile*). Figure 1 illustrates the relationship between these three different dimensions of learning styles and an explanation of each learning style.

Starting from the top level of the relationship which is Dimension 3 we have the following learning styles:

- **Visual Learners:** ***Learn through seeing*** .

Visual learners need to see the body language and facial expressions of the instructor to fully understand the content of a lesson. This type of learners may think in pictures and learn best from visual displays including: diagrams, animations, illustrated text books, overhead transparencies, videos, flipcharts and hand-outs. In addition, visual learners often prefer to take detailed notes during a lecture or classroom discussion to absorb the information.

- **Auditory Learners:** ***Learn through listening***

Hearing is the preferred sensory modality here. Auditory learners interpret the underlying meanings of speech through listening to tone of voice, pitch, speed and other

nuances. These learners learn best through verbal lectures, discussions, talking things through and listening to what others have to say and often benefit from reading text aloud and using a tape recorder. For these learners, written information may have little meaning until it is heard.

- **Tactile/Kinaesthetic Learners:** ***Learn through, moving, doing and touching***

The kinaesthetic learner learns best if given the opportunity to work with new information in a "hands-on" mode. These learners like to actively explore the physical world around them and would benefit from manipulating real objects and/or acting on them in a simulated environment. Tactile/Kinaesthetic learners may find it hard to sit still for long periods and may become distracted by their need for activity and exploration.

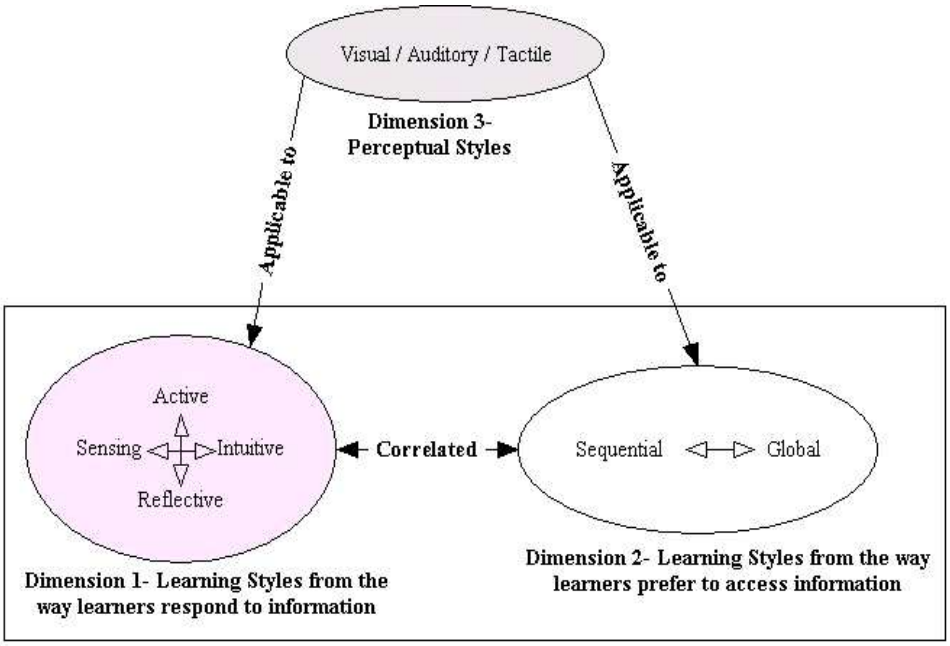

Figure 1 Relationship between the three dimensional learning styles.

It is argued in the literature that most people fall along a continuum of learning styles. They are probably not just an auditory learner, or just a tactile/kinaesthetic learner, but rather have aspects of all the categories, perhaps with one or two dominating. Multi-sensory instruction combines several teaching approaches, which allows learners to use more than one sense at a time. This is the most effective teaching method because it inundates the brain with the information in multiple ways.

Dimension 3 of learners' style is more universal and can be applied to any other type of learners identified with Dimension 1 and Dimension 2. It is independent of the two dimensions at the bottom. This means that an active learner can either be a visual learner or tactile learner and this knowledge doesn't affect the fact that the learner is active and prefer to interact with the information as explained below. The third

dimension is applicable at a later stage after identifying the learner's style with Dimension 1 and Dimension 2.

Dimension 1 enables the grouping of learners from their way of responding to learning materials. This Dimension is used before any other to clearly get a better picture of learners' preferences. It comprises two opposite pairs of learning styles as followed:

- **Active and Reflective learners**

Active learners tend to retain and understand information best by doing something active with it--discussing or applying it or explaining it to others. Reflective learners prefer to think about it quietly first. Active learners prefer group work more than reflective learners, who prefer working alone. Sitting through lectures without getting to do anything physical but take notes is hard for both learning types, but particularly hard for active learners.

Everybody is active sometimes and reflective sometimes. A preference for one category or the other may be strong, moderate, or mild. A balance of the two is desirable. If one always act before reflecting one can jump into things prematurely and get into trouble, while if one spend too much time reflecting one may never get anything done.

- **Sensing and Intuitive learners**

Sensing learners tend to learning facts whereas intuitive learners often prefer discovering possibilities and relationships. Sensors often like solving problems by well-established methods and dislike complications and surprises; intuitors like innovation and dislike repetition. Sensors are more likely than intuitors to resent being tested on material that has not been explicitly covered in class.

Sensors don't like courses that have no apparent connection to the real world; intuitors don't like "plug-and-chug" courses that involve a lot of memorization and routine calculations.

Our MPID approach uses extensively these key learning styles in order to categorise learners at the early stage of the instruction. Section 4 provides a detailed description of the way MPID exploits and realises these learners' preferences.

- **Sequential and Global learners**

Sequential learners tend to gain understanding in linear steps, with each step following logically from the previous one. Global learners tend to learn in large jumps, absorbing material almost randomly without seeing connections, and then suddenly "getting it". Sequential learners follow logical stepwise paths in finding solutions; global learners may be able to solve complex problems quickly or put things together in novel ways once they have grasped the big picture, but they may have difficulty explaining how they did it.

Dimension 2 is interrelated with Dimension 1 as it enhances learners' style profile by adding extra information related to the way they prefer to have access to learning materials. For instance, an active learner with a visual perceptual style can choose whether he or she wants to be presented with learning materials in a sequential manner (one step at a time) or globally (giving more flexibility to jump form one topic to another).

The combination of the above three dimensions help to better capture learner's preferences and enables instructional designers to become aware of their target audience and adjust their instructional design or delivery of learning content based on what is known about learners' characteristics. However, these three dimensions do not indicate the learner's past experience in terms of prior knowledge. If one's prior knowledge is known before the learning materials are packaged, learning would become more interesting and effective. Therefore, prior knowledge has been considered as a fourth dimension in figure 1.

Other types of learning styles are Cognitive styles which refer to the preferred way individuals process information. It is usually described as a personality dimension which influences attitudes, values, social interactions, and belief systems over the years. For example: field dependence vs. field independence refers to the way an individual tends to approach the world. A field dependent person tends to approach the world globally, where a field independent individual tends to approach it analytically. Knowing where the target learners' fall on this scale implies whether the instruction takes a holistic or parts approach.

3 Personalisation as a key function to support individual learning

One of the great advantages of using the web technology is that it can organise information to meet an individual's needs that is described as *personalisation*. Personalisation means styles of thinking, perception, and work performance are unique to any given person. Identifying these kinds of differences and then adapting the learning to them is necessary to achieving optimal performance from learners.

The key idea of personalisation is ***one- to- one*** activity as opposed to traditional ways of learning which are one-to-many activities. Personalisation includes using learner-specific strategies that may take many forms and offers alternative choices, including sequencing or presentation of content, practices, feedback, and assessments. Many instructors have been offering these personalisation strategies in classrooms for years. In online learning situations, technology should ensure that these strategies can be applied and increasingly self-managed by the online learners over time (Martinez, 2002).

Personalised e-learning and adaptive learning environments extend e-learning technology to individual and group learners; allow re-use of learning materials in different contexts; and provide individual learning experiences in an e-learning context. Few "one-size-fits-all" online learning models consider these important distinctions between learning types and, when necessary, try to manage these differences. Translating this kind of psychological information into learning strategies helps designers create learning situations that work best for the intended audience.

Personalisation can occur at different levels of the instructional process. The figure 2 describes the different levels of personalisation.

Personalisation can take place at a learning object level where the look and feel of the learning object is customisable to satisfy the needs of the learners. The look and feel elements comprise the choice of colours, font sizes of texts, and the overall layout of the content including animations and pictures quality.

Personalisation can also occur while learning materials are selected and learning contents are organised for the different types of learners. At this level, personalisation

determines learning strategies on information-push (I-Push), information pull (I-Pull) and blended learning (Reiser and Dempsey, 2002). Sequencing, as a mechanism to implement these strategies, enables instructional designers to structure learning materials in ways that meet the learners' requirements and prior-knowledge. Learning content is either pre-selected and then given to the learners (I-Push) or the learners can have some control over the presentation of the learning materials by choosing what they want to learn (I-Pull). The blended learning strategy suits the learner who requires a combination of I-Push and I-Pull during their learning process.

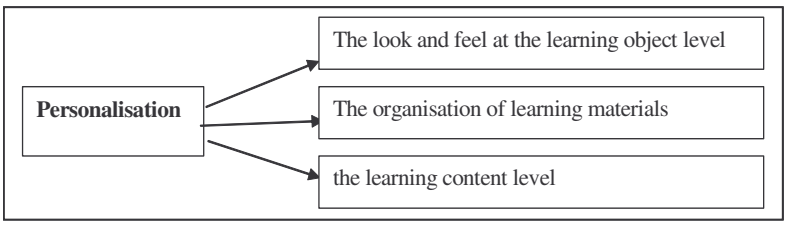

Figure 2 Three personalisation levels.

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A learner may require personalisation at different level at deferent stages of their learning during the learning process. A monitoring is a useful facility for tracking the learners' achievement throughout the learning process and provides the system with vital information on personalisation, such as learner's improvement or learners' difficulties with certain parts of the course. Instructional designers can use this feedback information to adjust the design of a course and provide better personalised support on learning.

4. The Architecture for MPID

The MPID architecture (figure 3) presents the main components which perform the functions of personalising learning materials to meet individual learner's learning requirements.

Learner access portal. All components H [1, 2, 3] perform the functions that allow learners to interact with the system by giving or obtaining information through their use.

Pre-test composer. After proper authentication, component [C] composes a pre-test which is used at the beginning of the learning process in order to identify the learners' preferences. The pre-test consists of two types of questionnaires. One for determining learners' style and the other one for identifying learners' level of prior-knowledge.

Learner profile. Results from the pre-test [C] will indicate the type of learner and his/her level of prior-knowledge of the course. This information constitutes the basis of each learner's profile [D] which is stored in [E], and will be used subsequently by the Matching Service [F] to provide personalised materials to each learner.

Matching Service. The Matching Service retrieves a specific learner's profile from [E] and carries out a mapping procedure based on the optimisation algorithms (Ousmanou, 2003). The results of this process will determine a selection of learning objects from the learning object repository [B] and their sequencing for the personalised learning package.

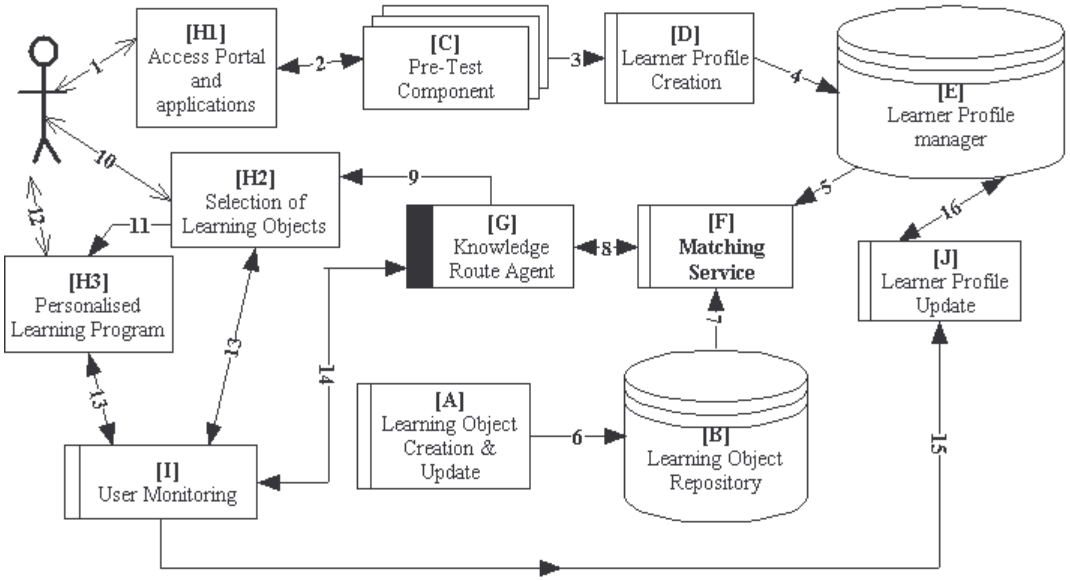

Figure 3 Architecture of MPID.

Personalised and updatable knowledge path. The knowledge route agent [G] basically is a piece of software which receives the matching outcome from [F] and manages the current knowledge path of the learner. These knowledge routes are presented according to different learners' profiles. For instance, a learner is identified as belonging to $profile_i$ from the pre-test and then he/ she is presented with *learning-object*(a, b, c) in the $learning\text{-}package_x$ from [F]. This set of information will be used for [I] monitoring the learning participation against the learning outcomes. An adequate support to individual learner can be provided at the right time. Furthermore, this information can be used to generate learning patterns which will improve the instructional design on personalised learning materials.

This architecture provides the software environment for learners to interact with their learning process and materials that allow them to engage learning with their learning experiences. All types of learners can be supported according to their learning styles and prior knowledge.

5. Identifying learning styles and assessing prior knowledge

MPID builds a learner's profile based on a combination of both their learning styles and prior-knowledge. We have devised a mechanism to identify the individual learner's learning style and assessing his/hers prior knowledge for formulating parameters for the optimisation algorithms in [F]. There are two main steps to carry out the analysis process.

The first step involves a design of questionnaires by which the learner's learning preference can be identified. As figure 1 exemplified, there are three dimensional factors influence learning styles. Dimension 1 shows two opposite pairs of learning styles (Active/Reflective and Sensing/Intuitive). These pairs reveal that there exist subcategories of learners who might have a combination of learning style rather that just

one style of either pairs. Figure 3 shows the possible valid combinations that may take place in a learning environment.

In addition to having learners with strong Active, Reflective, Sensing or Intuitive learning style; there is also the possibility of having learners with a mixture of learning style or learning preferences. The following represents the possible combinations of learning styles that a learner can have derived from figure 3.

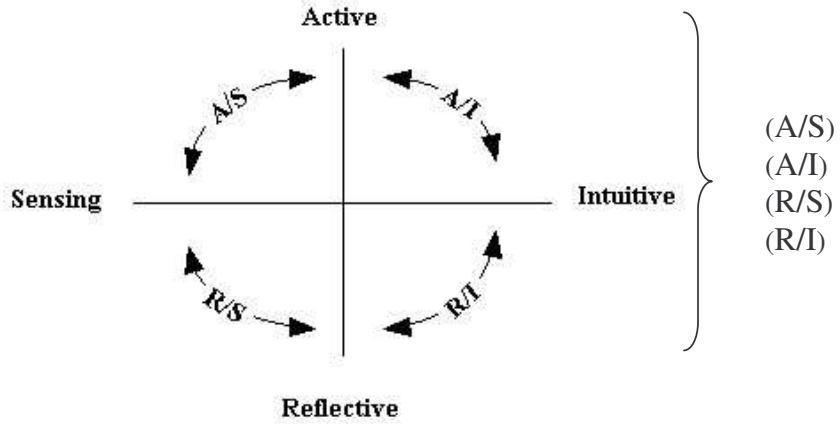

Figure 3 Patterns of learners' responding to information.

- **Active / Intuitive** (A/I): this type of learners, for instance, prefers discovering possibilities and relationships with learning materials actively. One possible way of satisfying (A/I) learners is by providing more examples within the learning materials, and links to further resources.
- **Reflective / Sensing** (R/S): learners belonging to this category like learning facts or factual information by thinking about it on their own first instead of working in a group. They would prefer to tackle to learning materials on their own first and then later on collaborate with other learners.
- **Reflective / Intuitive** (R/I): this type of learners would prefer to discover and explore relationships between learning materials on their own at first.

These subcategories of learners' style give a better understanding of the way learners interact with the learning materials. Based on these groups of styles, Dimension 2 is applied to further capture the way learners prefer their learning materials to be organised. Sequential learners as the name suggests, prefer to learn materials in a sequential manner by following logical stepwise paths in finding solutions whereas Global learners prefer to be presented with the overall big picture of the problem to solve at first and then work they way through it randomly.

This organisation of learning materials is somehow incomplete because of the lack of learners' level of background knowledge. This is where the fourth Dimension plays a vital role in assuring that adequate, relevant and personalised learning materials are

presented to learners based on their prior-knowledge. This is the knowledge or skills that learners possess before interacting with learning materials.

MPID is conceived as a solution to the deployment of an IT course entitled "C Programming Language" and this specific course is used to demonstrate how learners' prior-knowledge can be extracted and later on used in the pre-test. Three different levels of prior-knowledge were identified (i.e. background knowledge of the course which learners are about to take). These levels are: little prior-knowledge, enough prior-knowledge and good prior-knowledge explained as follows.

The following are learners' Prior-knowledge characteristics using the "C programming" course as an example:

- **Learners with "Little" Prior-knowledge**
  - Have never programmed in any programming language before.
  - A complete beginner. Have no notion of what a programming language is and how it is used to program something.
  - May have read about a programming language, but have never used one to program.

A I-PUSH learning strategy is suitable for the learner. The learning materials should be organised and presented in a step by step guide manner.

- **Learners with "Enough" Prior-knowledge**
  - Have programmed before using 1st and 2nd Generation languages such as assembler or Pascal
  - Have a notion of what a programming language is.
  - Have a vague understanding of programming languages concepts such as variables and arrays

The learners in this group require a blend of I-Push and I-Pull learning strategy. A balance between I-Push and I-Pull in delivery of learning materials can be determined by the categorised questions on in the prior knowledge questionnaire.

- **Learners with "Good" Prior-knowledge**
  - Have programmed before in before in 2nd and 3rd Generation languages such as Pascal, Delphi and Java.
  - Have a Good understanding of the key concepts of programming languages such as methods, functions, data structures or pointers.
  - May or may not have programmed before in C.
  - Understanding the difference between variable and constant and the concept of a Loop.

The learners in this group are considered that they are able to learn C programming language for the specifics. They can skip certain parts of materials as they have the knowledge and experience from other programming languages. A I-Pull learning strategy allows the flexibility on learning.

This grouping of learners based on their prior-knowledge can be generalised and used for any other course or any subject. Finally the last Dimension of learners' preferences (Dimension 3), which is applied after learners have been grouped, using Dimension 1, 2 and 4, is a more universal type of dimension which is in a way independent from the rest. It doesn't affect much the grouping, but rather enhance learners' profile by bringing information related to the way learners' want the learning materials to be presented to them. It will certainly affect the look and feel and the mean of presenting learning objects. Designing for Visual learners would require additional visual aids such as graphs, animations, picture or charts. Auditory learners would rather have sound files (for instance an audio tape of a lecturer explaining difficult concepts) or video with sound. Tactile learners would be satisfied with content such as "drag and drop" quizzes where they will need to use objects on screen as part of their learning experience.

6. Discussion and future work

MPID takes the four dimensional factors to determine the learners' requirements on personalised learning materials. A small scale of experiment has been carried out in our C programming language course. A prototype system has been developed that can establish the learner's level of competence and preferred styles of learning. The prototype will then dynamically create a personalized set of learning material that can be used to support the learner. This development aligns with the institutional teaching and learning strategy for improving higher education and it is the important point software solution within the generic framework for e-learning within the university. MPID will be piloted in many other courses across the university. The experience and feedback on the use of this method from both learners and instructors will be systematically acquired to establish the best practice patterns.

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