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Citation: Walton, Geoff and Hepworth, Mark (2011) A longitudinal study of changes in learners' cognitive states during and following an information literacy teaching intervention. *Journal of Documentation*, 67 (3). pp. 449-479. ISSN 0222-0418

Published by: Emerald

URL: <http://dx.doi.org/10.1108/00220411111124541>
<<http://dx.doi.org/10.1108/00220411111124541>>

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A longitudinal study of changes in learners' cognitive states during and following an information literacy teaching intervention

Abstract

Purpose

The paper identifies the changes in cognition associated with becoming information literate, specifically, in relation to the evaluation of information. Additionally, it puts forward a model for a teaching and learning intervention that engages the learner and leads to higher order information literacy (IL) thinking. From a theoretical perspective the research integrates ideas from the fields of IL, teaching and learning, e-learning and information behaviour (IB).

Design/methodology/approach

Three interventions were designed to develop the information literacies of first-year undergraduates studying Sport & Exercise at Staffordshire University, to teach and test IL. Interventions took a blended approach and combined face-to-face and online social network learning (OSNL) – also referred to as social media learning (SML) - and focused on one aspect of information literacy: the ability to evaluate source material. Data was captured via interviews, focus groups and from the online discussion that was analysed thematically and categorised using task, behaviour, cognitive states, affective states, conative states and knowledge. This helped to evaluate the efficacy of the interventions and provided data for further analysis. This paper focuses on the cognitive data and their transitions during the interventions and, in particular, among those respondents who experienced OSNL.

Findings

The changing cognitive states, associated with IL learning were modelled and made evident key cognitive states and transitions. This is represented in the paper in diagrammatic and mathematical notation. The findings indicate the complexity of the information behaviours associated with IL including the cognitive, behavioural, conative and affective elements. Although the cognitive transitions are the focus of this paper an insight is also given into an IL intervention that fosters the capability to interact critically and reflectively with information. The pedagogy that underpins these changes is indicated. The intervention, which incorporated OSNL, proved the most successful.

Research limitations/implications

Undergraduate students' IB can be changed and IL developed. Additional long-term data would have indicated whether this intervention had a lasting impact on the undergraduates.

Practical implications

IL practitioners should consider incorporating OSNL and assessment in their interventions. Incorporating discussion, reflection and peer-to-peer assessment is likely to lead to deeper learning when teaching IL.

Originality/value

The research adds detail to our understanding of the cognitive, behavioural, affective and conative states associated with IL and makes explicit how these may change as the learner becomes information literate.

Keywords: Information literacy, information behaviour, e-learning, online social network learning, social media, social media learning, cognition, critical thinking

Paper type: Research paper

1. Introduction

To gain an understanding and acceptance of information literacy (IL) as a fundamental part of the learning process any learning and teaching intervention should be based on a bedrock of learning theory and pedagogical practice. In this case Bloom et al's (1956) cognitive states and constructivist approaches to learning as exemplified by MacKeracher (2004). Developments in e-learning offer a rich seam of pedagogical possibility important for facilitating IL learning (Salmon 2002). Furthermore, the expanding field of information behaviour (IB) research offers empirical insights into how people seek out and use information, especially the model devised by Hepworth (2004). These provide high level frameworks within which IL can be set and indicate factors that should be taken into account when researching IL. These theoretical orientations have not been integrated hitherto. In this research the importance of this nexus was recognised and drew on an existing IB framework and used this to guide data collection and designed and implemented a series of IL interventions that were underpinned by learning and e-learning theory. The objective was partly pragmatic i.e., to develop an effective IL intervention that could be delivered to undergraduates within HE drawing on the work of IL authors, such as, Andretta (2007) and IL frameworks, such as, SCONUL (1999) and ACRL (2000). Specifically the intervention concerned those IL skills and knowledge associated with evaluating information sources. However, an insight was also gained into the cognitive processes and, to a lesser extent, the affective and the conative state of the learner, associated with becoming information literate over a period of time. At a theoretical level, therefore, this research helps to make explicit the 'thinking' (cognition) that relates to one particular, fundamental, aspect of information literacy i.e., a critical approach to evaluating sources of information.

This, in turn, led to an insight into levels of 'thinking' associated with evaluation. Being able to distinguish between different levels of thinking and cognitive changes enables the formulation of explicit learning outcomes and the evaluation of an intervention.

2. Literature review

The term *Information literacy* has seen wide and varied use since its inception in 1974 (Bruce, 1995; Andretta, 2005) and it is recognised throughout the world (Andretta, 2007). The information profession has, and continues to, put forward the IL cause with a near-missionary zeal and though neatly packaged is regarded by some as a dangerously ambiguous concept, which is not easy to interpret or apply (Owusu-Ansah, 2003). Whilst there is a minority view which questions the actual worth of IL as an educational endeavour (Wilder, 2005; Williams, 2006) a more scholarly critique of IL is emerging e.g., Whitworth (2007) and Markless & Streetfield (2007). Recent research even questions whether student information behaviours can be changed once they enter HE (UCL, 2008), whereas, in this study, significant changes were evident. Many definitions of IL exist (Andretta, 2007) e.g., ACRL (2000), Bundy (2004), Big Blue (2002) and SCONUL (1999) to name but a few. An emerging body of work in IL and the workplace has recently emerged (Conroy, 2006; Lloyd 2007; Hepworth & Smith 2008). There has been much debate regarding the terms *information* and *literacy* and the arguments for and against using these (Owusu-Ansah, 2003), whether they should be used together (Loveless & Longman, 1998) and what they mean (Case, 2002; Lloyd, 2003; Saranto & Hovenga, 2004; Andretta, 2005). Despite this, IL continues to be discussed and this debate has reached the global arena in which there have been several pronouncements. The *Prague Declaration* (resulting from a UNESCO-sponsored conference and reported in USNCLIS (2003), reiterated by the *Alexandria Proclamation* (UNESCO, 2005) and the recent US *Presidential Proclamation* on IL (Obama, 2009) has added weight to the importance of the concept and seeks to argue that IL is not only an important set of skills to enable information to be gathered and used but also essential for effective participation in the 'information society' and a basic human right, statements reminiscent of the comments made by Kuhlthau (1987, quoted in Bawden & Robinson 2002, p297). Furthermore, the connection between information literacy, human capital and capability building is becoming evident (Hepworth & Walton, 2009) and in this study the need and ability to evaluate information.

The number of textbooks devoted to advising practitioners, from a range of disciplines, sectors and professions, on how to teach information literacy continues to grow e.g., Grassian & Kaplowitz (2001), Shinew & Walter (2003), Webb & Powis (2004), Cook & Cooper (2006), Secker, Boden & Price (2007) and Hepworth & Walton (2009). It has generally been accepted that IL instruction requires a shift, as in this study, from teaching how to use specific resources to a set of critical thinking skills involving the use of information (Kasowitz-Scheer & Pasqualoni, 2002) and this is reflected in some in recent research in IL and teaching and learning (Bordinaro & Richardson, 2004 and Walker & Engel, 2004). Other more complex approaches have been analysed by Bruce et al (2007). Some argue that the range of cognitive skills achievable by following an IL model, as defined by Bloom et al (1956), can be attained by all within IL (ACRL, 2000) whereas others (e.g. SCONUL, 1999) regard higher order cognitive skills as only achievable by postgraduates. This was found not to be the case in this study where Bloom's framework was used to categorise different cognitive states of the learner. The most

significant IL initiatives have taken place in the United States and Australia/ New Zealand (Virkus, 2003). There are also references to IL developments in specific countries such as, China, Japan, Mexico, Namibia, Singapore, South Africa (Virkus, 2003), Canada (Julien & Boon, 2002) and Turkey (Kurbanoglu, 2004). IFLA (the International Federation of Library Associations) has developed a definition (Lau, 2006) that is intended for application in any national context. IFLA continue to be active in this arena (IFLA, 2009). Within the European Union (EU) there were a number of IL initiatives reported in local EU languages e.g., Danish, Dutch, Finnish, French, German, Norwegian and Spanish amongst others (Virkus, 2003). Finland in particular is regarded as world leader devising an IL policy, which has been implemented within its education system (UNESCO, 2005). It is also evident from recent Librarians Information Literacy Annual Conferences (LILAC) and the Umbrella Conference that practitioners continue to develop innovative context specific IL interventions (for example, Cousins & Perris, 2009; Bent & Stockdale, 2009; Stubbings, 2009).

Information literacy here is defined as:

a complex set of abilities which enable individuals to: engage critically with and make sense of the world, its knowledge and participate effectively in learning to make use of the information landscape as well as contributing to it.

Hepworth & Walton (2009, p10)

However, despite the many and varied definitions and models of IL, it would appear that IL models are insufficient in themselves in addressing the issues that contribute to effective information behaviour which enable people to become information literate (Markless & Streatfield, 2007; Walton, 2009) and do not recognise the importance of context. Lloyd's (2007) work is a notable exception. This is apparent when IL models are compared with IB models such as those devised by Dervin (1983), Kuhlthau (1991), Wilson (1999), Ford (2004) and Hepworth (2004) or those reported and analysed by Fisher, Erdelez, & McKeachie (2005) and Case (2007). Existing IL models do not, it is argued, reveal in sufficient detail the complex nature of the process of becoming information literate (Walton, 2009). Cheuk (1998; 2002) and Hepworth (2003), for example, note that carrying out a search in order to retrieve information is a highly complex iterative activity in that it can: involve progress and abandonment; be by turns ordered, disordered and regular. Neither do IL models appear to take sufficient account of the underlying pedagogic issues that underpin successful IL teaching and learning (Walton, 2009). IL models tend to describe the process of learning to become information literate as going forward in an orderly fashion. However, the ACRL (2000) model is based upon Bloom's cognitive taxonomy of learning (Bloom et al, 1956) and recognises a number of cognitive stages to the learning process namely knowledge, comprehension, application analysis, synthesis and evaluation. Most IL models imply a progressive, orderly, sequential process that contrasts with the writings of authors in the field of teaching and learning such as, Squires (1994), Gibbs et al (1998), and Race (2001a), who, akin to experts in IB, state that learning in general is probably

not an orderly activity. As a result an iterative approach to the learning intervention was followed. The favoured approach to learning is the construction of meaning via conversation and ongoing negotiation between learners and their tutors (D'Andrea, 1999; Fry et al, 1999; Wenger, 1999; Laurillard, 2002; MacKeracher, 2004; JISC, 2004) which is argued can promote the desired outcome of 'deep learning' as identified by Marton & Saljo (1997) or 'extended abstract thinking' as identified by Biggs (1997). However, to achieve this with a large cohort of learners is challenging, hence, the attraction of achieving this via e-learning as applied in this study.

Current approaches to IL can be perceived as providing educational goals that indicate broad, high level, largely behavioural, processes. However, it is argued that IL should also be defined in terms of cognition and as a thinking skills framework that enables this goal to be realised. This study, therefore, attempts to clarify the cognitive states and transitions associated with one aspect of IL. Furthermore, it is postulated that only through goal-centred activity, such as problem-based learning (Mason, 2004) involving learning by doing (Kolb et al, 1991), will this really occur. These modes of activity can be supported in the PC lab by the technique of 'touring' to ensure that students are engaged and on task (Gibbs, 1998). This intentional goal-orientated behaviour, especially in the electronic domain, carried out by the learner whilst for example, doing a database search facilitates and strengthens connections between retrieving information and using it in an appropriate context resulting in higher-order thinking and meaningful learning (Jonassen et al, 1995). Salmon (2002), Garrison et al (2003), Nicol, Minty & Sinclair (2003), Mayes & DeFreitas (2004; 2007), McConnell (2006), Beetham & Sharpe (2007), Walton et al, (2007a & b), Godwin & Parker (2008) all note the power of online discourse in learning. In recognition of these issues it is recommended that IL i.e., 'being information literate' should be regarded as a metacognitive tool which provides a self-regulatory framework within a subject based programme (Wolf, Brush & Sayer, 2003; Lowe & Eisenberg, 2005). Moseley et al (2004) in their review of thinking skills theories note that metacognition is fundamental to learning because it aids the learner to monitor, evaluate and change as they progress and gives rise to further learning and understanding, a view held by earlier writers such as Biggs & Moore (1993) and Metcalfe (1994). It is with these issues in mind that IL was delivered in the study analysed here.

3. Methodology

To investigate these issues three IL interventions were designed. The objective of the analysis of the data was to test whether an intervention, which is problem-based involves face-to-face and online delivery and where learning by doing is the central pedagogical technique, can reveal the cognitive states and transitions associated with learning to become information literate. The notions of courseware devised by Mayes (1995) were used to design the interventions and structure the groups. Mayes (1995), reiterated by Goodyear (2001), draws a distinction between three levels of courseware used in e-learning contexts, that of primary, secondary and tertiary.

- 'Primary courseware' is used principally to convey information to students such as online lecture notes and reading lists (Littlejohn & Higgison, 2003; JISC, 2004). Mayes (1995) and Goodyear (2001) regard this courseware as only useful in the conceptualisation stage of learning where students are exposed to other people's ideas and concepts (JISC, 2004).
- 'Secondary courseware' is used largely to question and encourage reflection in students via online tests and quizzes (Littlejohn & Higgison, 2003). These are regarded as tools for carrying out learning tasks (Mayes & de Freitas, 2004) one example would be computer aided assessment (JISC, 2004). Mayes regards this courseware as vital to the construction stage of learning where learners apply new concepts in meaningful tasks (JISC, 2004).
- 'Tertiary courseware' enables the production of materials by previous and current learners in the course of discussing and assessing their learning such as, dialogue between learner and tutor or peer discussion or assessment outputs to be captured and made available for all learners. In effect, 'tertiary courseware' creates a 'cognitive space' (Garrison et al, 2003) where students can give a far more considered reply online than in the immediacy of a face-to-face conversation. McConnell (2006) regards this social dimension, embodied in online discussion and dialogue, as an essential pre-requisite in fostering effective online learning.

Three groups of UK based first-year Sport & Exercise undergraduate students were involved in the study. The Faculty administration team allocated students to their tutor group alphabetically by surname (effectively at random) and all were reading for the BA award. All students were from the UK, between the ages of 18 to 20, English speaking and had completed 'A' levels at their local Further Education college (normally this includes study skills support but not specific interventions in information literacy). The gender balance was 65% male and 35% female. The study was conducted in Semester 1 of academic year 2006-07.

Levels of online intervention were structured to reflect the courseware definitions as shown. Each group received a separate intervention as outlined below.

Group A (experimental group, n=17)

1. One 50-minute workshop delivered face-to-face to students;
2. One 50-minute session workshop delivered (in blended fashion) each week for 4 weeks using OSNL techniques (tertiary courseware) that gave access to primary courseware elements, e.g. web pages and online course documents and secondary courseware elements, e.g. interactive online quizzes.

Data was gathered from, pre and post-delivery diagnostic tests, focus group responses, post-delivery questionnaire responses, written assessed work, online discourse and interview responses from the module leader.

Group B (intermediate group, n=17)

1. As per Group A;
2. One 50-minute session workshop delivered (in blended fashion) each week for 4 weeks with access to secondary courseware techniques such as interactive online quizzes (this also contained primary courseware elements, e.g. web pages and online course documents).

Data was gathered from, pre and post-delivery diagnostic tests, written assessed work and interview responses from the module leader.

Group C (control group, n=12)

1. As per Groups A and B;
2. Access to primary courseware elements, e.g. web pages and online course documents only for the subsequent 4 weeks.

Data was gathered from, pre and post-delivery diagnostic tests, written assessed work and interview responses from the module leader.

In this article, because only group A experienced the OSNL during the course of the module, it is only data from group A which is analysed in terms of cognitive states. However, data from all groups gleaned from the written assignment is introduced for comparative purposes.

The learning outcomes (LO) taken from the module handbook and addressed by the learning and teaching interventions discussed here were:

“1. Demonstrate knowledge of a range of skills required for effective learning, including [...] use of library learning resources to identify suitable information sources [...]

3. Information Technology Skills: Be able to use a windows environment to manipulate information [...].”

The more detailed intended learning outcomes devised to address LO 1 and 3 were:

“The face-to-face session is designed to enable students to address their information need in order to retrieve appropriate information for their assignment.

At the end of the session students will be able to:

- Recognise their information need by identifying appropriate keywords;
- Use common Boolean terms ‘and’ ‘or’, ‘not’ to construct a simple search strategy;
- Identify appropriate electronic resources such as the Library Catalogue, e-journals and e-books and use them appropriately by:
 - Exploiting the Library Catalogue through:

- Locating it on the web;
 - Using the **Alphabetical** facility to find book, e-book and journal resources;
 - Using the Advanced search facility to find resources on a particular topic,
 - Locating books and journals on the shelves.
- Exploiting E-journal resources through:
 - Locating it on the web;
 - Using the search facility to find appropriate journal articles including;
 - Simple keyword searches;
 - Phrase searching;
 - Using truncation and wildcards;
 - A combination of the above search tools to create a search strategy;
 - Using navigation tools to read and/ or print journal articles;
 - Transfer e-journal searching skills to other appropriate e-resources.

The Online Social Network Learning Activities are designed to enable students, through online discussion, to evaluate information sources for inclusion in their assignment.

In completing OSNL Activities students will be able to systematically evaluate web sites by using an agreed set of criteria identified via discussion.”

For their assignment all students were given the problem of finding and evaluating six information sources on football hooliganism to create a fictitious presentation for a group of young people.

Group C can be regarded as the control group because they received the IL delivery pattern students would normally receive if this research had not taken place. During the research period Groups B and C did not experience OSNL.

The way in which the IL teaching and learning intervention was structured is illustrated in detail here (see Table 1). This structure emerged after testing via a Pilot Study that was reported in Walton et al (2007a and b). The online social network learning process is shown in Figure 1. Data was collected at each stage of the process and the cognitive states and transitions are visualised in Figures 2, 3, 4 and 5.

Table 1: Overall IL intervention model

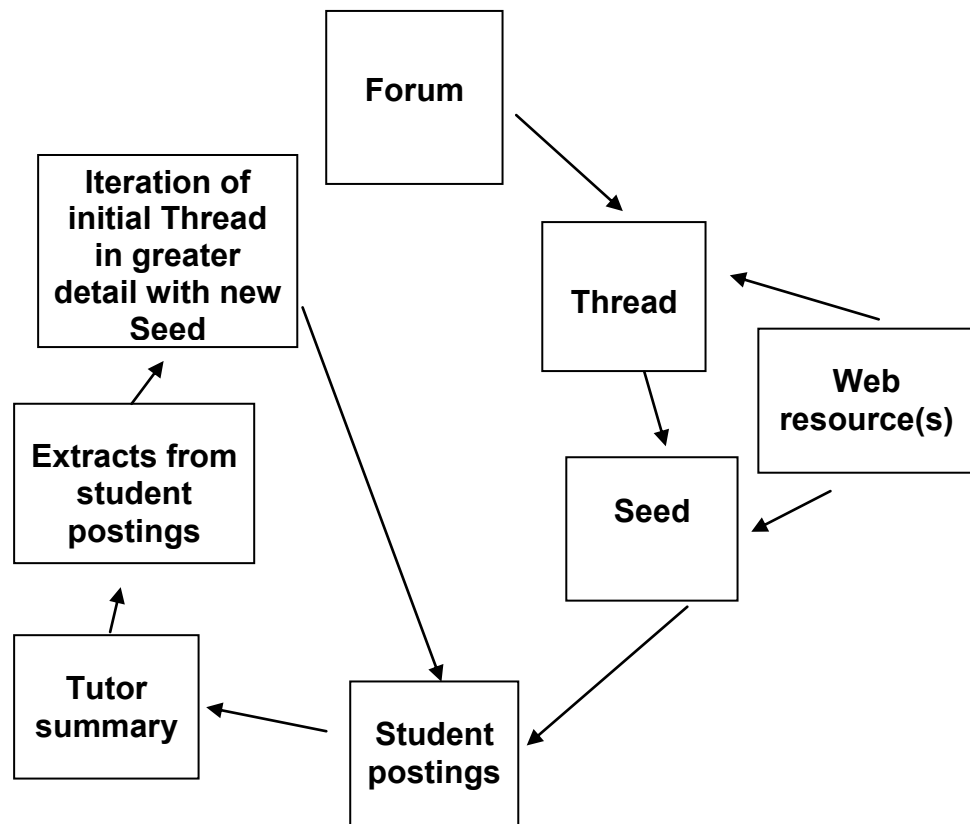
Information literacy component	<i>Make use of the information landscape</i>	<i>Engage critically with knowledge and information</i>	<i>Engage critically with knowledge and information</i>	<i>Make sense of the world, its knowledge and contribute to it</i>
Teaching and learning intervention	Workshop	Discussion	Discussion	Assessment
Mode	Face-to-face	OSNL (first posting)	OSNL (second posting)	Written work
Illustration of observed processes for a particular mode	Figure 2	Figures 3 (see Figure 1 for OSNL structure)	Figures 4 (see Figure 1 for OSNL structure)	Figure 5

The model shows the sequence of specific interventions which embody the *pedagogical intervention* itself namely the *face-to-face workshop*, the *OSNL activities* and the *written assignment*.

The face-to-face workshop included a short exposition and then students used a worksheet which contained exercises to enable students to find information on the library catalogue (25mins) and an e-journals package (15mins). Each segment included a short group discussion on identifying appropriate keywords using a questioning approach following MacKeracher (2004). The workshop concluded with a plenary summarising what had been learnt.

The OSNL activities were presented in the Blackboard VLE (illustrated in Figure 1).

Figure 1: OSNL process



In summary, the *Forum* contains the title of the activity and some general guidance for example, *“This discussion is designed to help you with your assignment. Please open this discussion forum by selecting the title above and follow the instructions contained within the thread message”*. The *Thread* is the first posting by the tutor in the discussion board and contains more specific instructions and the *Seed* text which is set up to foster discussion for example,

“for this activity last year a student commented that she, ‘always ensures that a web page is reliable before using any information on it’. So, how would you decide what makes a reliable, good quality web page?”

This was followed by very specific instructions and web resources to read. Once students had looked at a sample web page and evaluated using the resources provided they then summarised, in their own words, their evaluation criteria and posted it to the discussion board. Students would then comment on their fellow students postings. At the end of this part of discussion the tutor would then create a *tutor summary* which is couched in the first person and used first names and used extracts from students postings as a means of carrying on the discussion in more depth or *Iteration of initial Thread in greater detail with a new seed* for example, *“Ringo mentioned that a good way of judging a web page can be done by ‘looking at the URL address and*

seeing whether it is for example a government source'. [We] agree with Ringo regarding URLs BUT stress that we need to be more systematic in the way we analyse their structure. Have a look at the web resource and discuss how we might be more systematic in analyzing a URL."

Evidence presented here centres on Focus Group responses (members were selected at random from Group A) and was corroborated, where appropriate, by other data such as questionnaire responses, online discourse and written assessment data. From the verbal and written data provided by interviewees and participants the behaviours associated with information literacy were identified. These provide, in a sense a verbal and written log of activities undertaken by the student and indirectly an audit of information behaviours that to a greater or lesser extent the learner had implemented.

Data from the OSNL discourse, focus group responses and the written assessment were coded using Hepworth's model of information behaviour (Hepworth, 2004). These included the following categories: *Task, Behaviour, Cognitive State, Affective State, Style State, Source Character* and *Source Behaviour*. Task relates to the task undertaken by the learner i.e. learning how to use e-resources. Behaviour refers to the actions of the learner, such as, viewing a web site. Cognitive State refers to the thinking processes such as, comprehension or analysis. Affective State relates to the emotional state of the learner including uncertainty. Style State refers to learning style and also the conative state of the learner including positive and negative states of motivation. Source behaviour and character relate to the properties of informing artefacts, such as Web resources and their functionality but also includes the teacher and fellow students who in this sense are a source of information and exhibit specific behaviours. In addition, Bloom's Taxonomy the cognitive learning domain (Bloom et al, 1956): *Knowledge, Comprehension, Analysis, Application, Synthesis, Evaluation. Cognitive Questioning* (a category which emerged from the data) and Moseley et al's definition of *Metacognition* (Moseley et al, 2004) provided extra coding dimensions to further articulate the knowledge and cognitive states identified in Hepworth's model.

4. Data from focus group responses concerning the face-to-face workshop

In IB terms, the whole activity was defined by the *task* (see figure 2). This was designed to enable students to use a range of e-resources to find and evaluate books, journal articles and web resources. Each student engaged in some *behaviour* e.g., "*search for books*" which in turn led students to exhibit a number of concurrent cognitive states that included *application* and *comprehension* when they interacted or experienced information sources. *Application* was evidenced in that all students found material for their assignment experienced in tandem with *comprehension* e.g., "*the keyword we did the searches for*". These *cognitive states* were triggered via experiencing source character both in terms of artefacts e.g., "*the library catalogue*" and people e.g., "*library staff*". Experience of *source character* was also paralleled with experience of *source behaviour* e.g., "*you can look for a certain subject*"

and tutor as source e.g., “*you showed us what to do*”. These appear to be underpinned by a *metacognitive state* or a realisation that something had been learnt e.g., “*I learnt quite a few things*” which again appear to operate concurrently with the *cognitive states* mentioned above. At the end of the session via these processes students arrived at the *cognitive state* of *new knowledge* e.g., “*I have learnt how to use Swetswise*” which in turn led to *new behaviour* e.g., “*I have been able to find more in depth information*” and hence *task completion* e.g., “*I can use the online library to search for e-books and books*”.

It was also noted that that students reacted very positively towards the way in which the *face-to-face workshop* was delivered. An example of this positive *affective state* was revealed through making sure that students felt supported whilst they completed a *task*, “*you, like, came around [in class] and made sure that we were all at the same stage and all keeping up to date and I appreciated that*”. This evidences the pedagogical technique of ‘touring’ (Gibbs, 1998, p15) within a small group hands-on workshop which was employed here. Here the tutor acts as an information source and their behaviour is perceived by the learner and affects their ‘state’. In addition, this appeared to uphold Gibbs’ (1998) view that this form of delivery is best suited in this context here and supported different learning styles (learning by seeing, learning by doing, learning by reading and learning by writing) and was associated with a positive *affective state* among the students. It is argued that by enabling these states to occur it became more likely that *new knowledge* was learnt which promoted the *new behaviour* enabling *task completion*.

Figure 2: Observed cognitive states during the face-to-face workshop

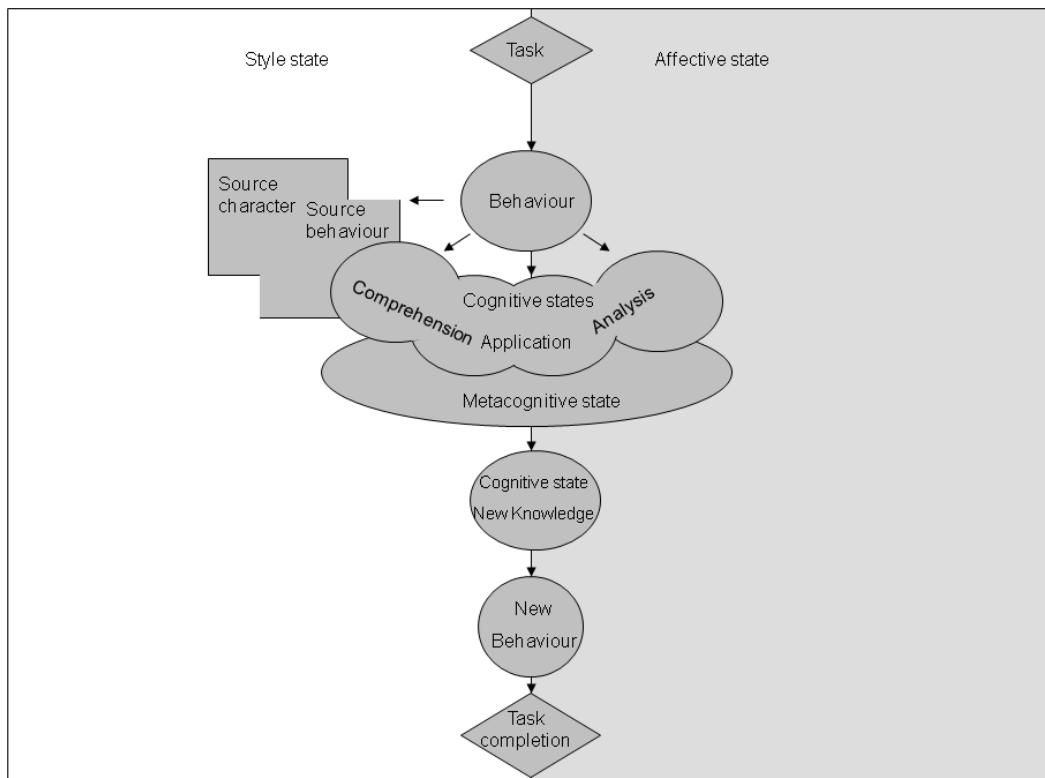


Figure 2 illustrates how the students' behaviour (the interaction with an information source), subsequent cognitive, metacognitive, new knowledge and new behaviour are triggered by the task and underpinned by the style and affective states.

5. Data from focus group responses and questionnaire concerning OSNL activities

Figure 3: OSNL activities: Observed cognitive states in making a first posting

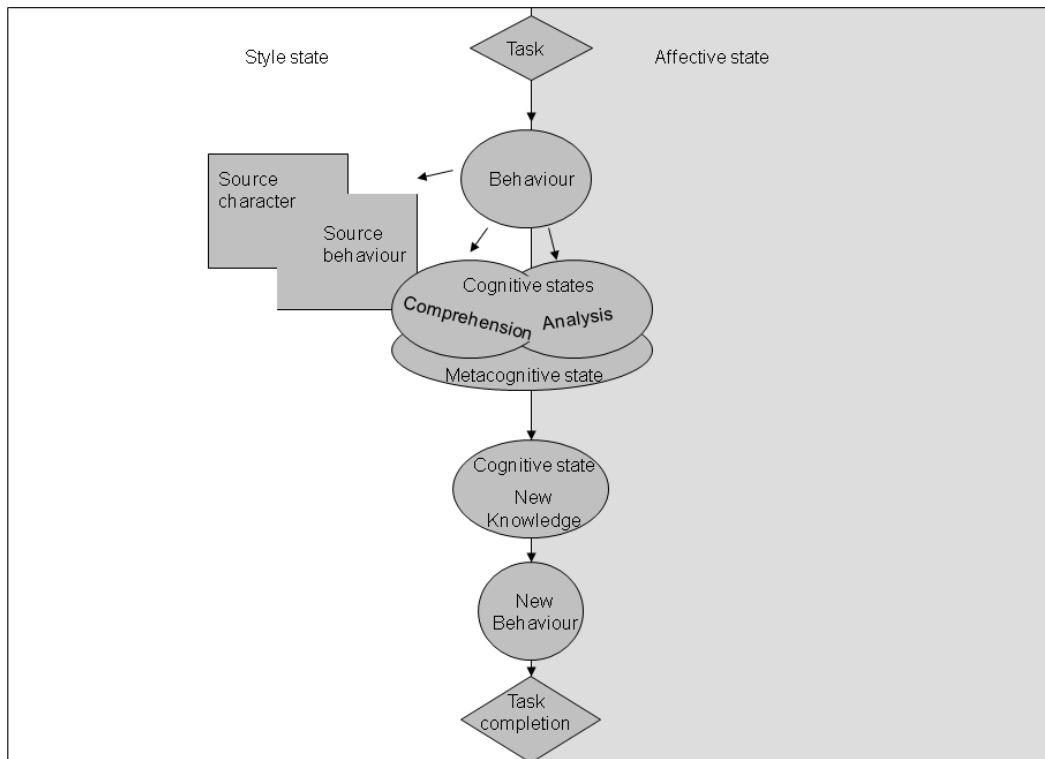


Figure 3 illustrates, in schematic form, how the students' behaviour (the interaction with an information source), subsequent cognitive, metacognitive, new knowledge and new behaviour are triggered by the task and underpinned by the style and affective states.

From this initial *task* a set of behaviours and states emerged (see figure 4). Students engaged in some *behaviour*, “log onto Blackboard” and “read the article”. Students then engaged with the two sources the “article” (Berkeley web site on evaluating information), then in the *behaviour* of browsing the web sites and then the *cognitive* process of analysing and evaluating a web site (one example being the BBC sports section) exemplified in the statements, “we went through different websites, having a look, how reliable they were, evaluating what you think” and comprehended some of the source characteristics. In effect students began to evaluate the web site and mentioned criteria such as “URL”, “relevant”, “reliable date” and “check the author” which enabled them to produce their own evaluation criteria (*new knowledge*) and then engage in some *behaviour* e.g., “writ (sic) paragraphs on what I thought was important”.

In short via OSNL students appeared to become highly focussed on the *task*, began to engage in high level cognitive processes and demonstrate an emerging set of IL skills associated with evaluating web-based information. This outcome supports the view put forward by Goodyear (2001) and Mayes

& de Freitas (2004) that by scaffolding online learning interventions in this way with clear instructions and which set questions to be answered, rather than information to be absorbed, can enable students to create their own meaning regarding a topic and hence engender learning. This was evidenced by the fact that students created postings which were couched in their own words (indicating Bloom et al's cognitive process of *comprehension*) and with content which demonstrated that they had made judgements about what to include. The following initial student postings illustrate this:

Student A: *"When looking at a website it is important to check the author or who it was created by. You can check if it is a government website by looking at the web address. Some websites have headings saying, 'Background' or 'who am I (sic)?' this enables somebody to look for reliability."*

Student B: *"I would evaluate a web page by; looking at the URL address and seeing whether it is e.g. a government source, which would mean the source is reliable. You can also look at the author and find out whether (sic) they have a good reliable background and you should also be able to find any related links and other sources used. Finally look at the last time when the web page was updated especially when stats are involved."*

This is evidence of the cognitive process of *analysis* (Bloom et al, 1956), and critical thinking identified by Moseley et al (2004), that is, they had analysed the source they were given to use.

Hence, the e-learning model appeared to enable students not only to read information about evaluating web site but also to begin through posting messages to Blackboard to create, via *analysis*, their own evaluation criteria. In turn they began to create a shared meaning regarding this topic leading to a transformation in students understanding of reality, the central tenet of constructivist pedagogy (Kolb et al, 1991) and dialectical learning (MacKeracher, 2004). This is evident from students' comments, discussed below, where they recognise the value of sharing and reflecting on each other's online postings. In essence the students engaged in an online collaborative conversation which Laurillard (2002), Jonassen et al (1995) and MacKeracher (2004) argue is an essential component in enabling students to negotiate the meaning of phenomena and also defines the nature of 'tertiary courseware' (Mayes, 1995; Goodyear, 2001; JISC, 2004). This corroborates Goodyear (2001) who states that this particular e-learning pedagogical intervention is the most appropriate in fostering this outcome. It can therefore be asserted that it is only by harnessing the pedagogical intervention described here that the higher order thinking skills necessary for IL will be realised.

In addition, it can be seen that during this stage the students' *affective state* underwent a transformation from feelings of *uncertainty* in that they felt that they did not know anything regarding the task e.g., *"at first I didn't get it"* to a later state of reduced *uncertainty* in that they have a feeling of having done

something “*productive*” by making a posting. This positive feeling appears to lead to a sense of motivation e.g., “*it gets people quite motivated to do things*”. There is little reference to motivation in IL models (with the exception of the IFLA guidelines (Lau,2006) - to which the first author contributed) and the work of Jacobson & Xu (2004) and yet it is referred to in IB models (Wilson, 1999) and in learning (Race, 2001a), e-learning theory (Mayes & de Freitas, 2004) and pedagogy (Fry et al, 1999). One implication of this study is that motivation deserves greater emphasis in IL teaching and learning.

In tandem with the transformation in *affective state* the *style state* appears to be positive throughout because students feel that they are doing something constructive and making sense whether it be reading e.g., “*I learn by seeing*”, or writing e.g., “*writ (sic) about the actual points*” or “*posting a bulletin*” rather than being a passive recipient e.g., “*it was quite fun rather than being lectured to*” again demonstrating that this intervention bore the hallmark of a constructivist approach as described by Mayes & de Freitas (2004).

Figure 4 represents the processes experienced by students as they replied to initial postings and denotes the next stage in the OSNL process. It should be noted that the observed IB and cognitive processes involved in this stage differ from that of the initial posting shown in Figure 3 and incorporates the cognitive state of *questioning*.

Figure 4: OSNL Activities: Observed cognitive states during completion of second posting

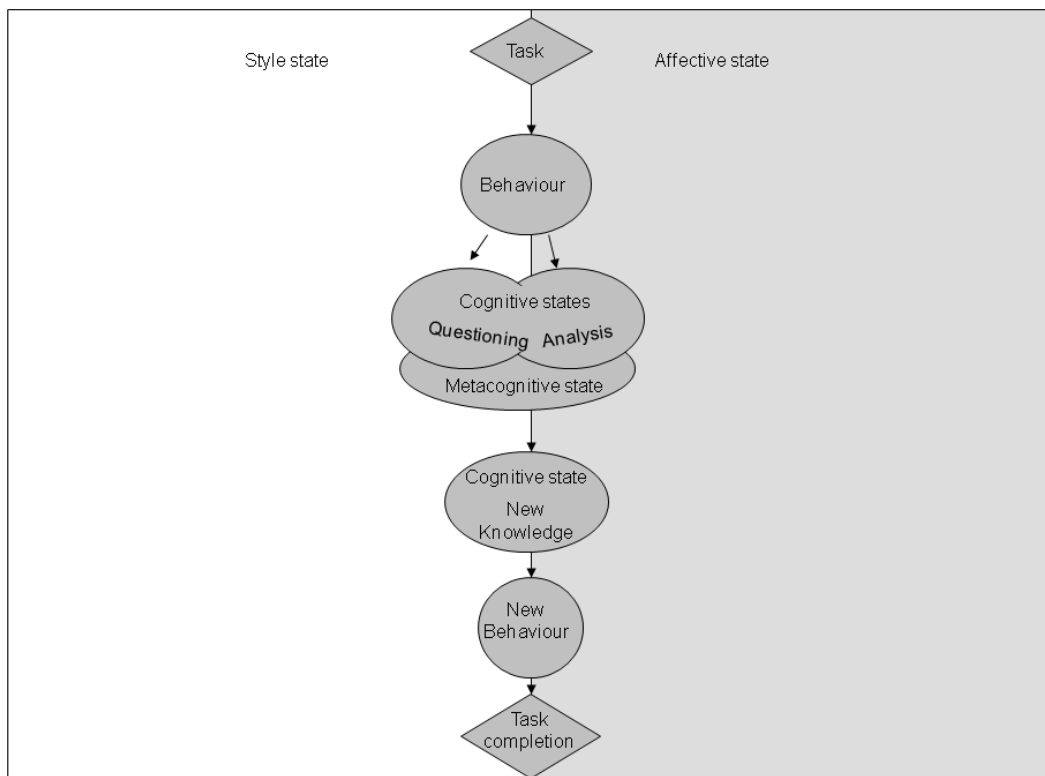


Figure 4 illustrates how the students' behaviour (the interaction with fellow students), subsequent cognitive, metacognitive, new knowledge and new behaviour are triggered by the task and underpinned by the style and affective states.

The student's *behaviour* was defined by the *task* that was to, "feedback on each others" work. The behaviour itself involved reading and replying to another's posting e.g., "I was commenting on his, he was commenting on mine" and then a series of concurrent processes appear to have taken place. The student appears to enter a *cognitive questioning* state e.g., 'I was writing about how he hadn't actually writ (sic) about all the actual points you were meant to evaluate'. This led to an analysis of the fellow students posting e.g., "he hadn't really researched football hooliganism on the FA website". This was mediated by the *metacognitive state* where students begin to realise that they may have missed something out or hadn't looked at something when they did their own first posting e.g., "you got to see what you was (sic) missing or something you hadn't looked at" and "obviously you always think your own work is perfect, sometimes it's a bit of an eye opener when somebody says you should have done this, gets you thinking about it". This *cognitive questioning state* appears to create in the student's mind a sense of an information gap that is identified both by IB (Dervin, 1983) and IL (SCONUL, 1999) as part of the initial process in seeking information. This, it should be noted, came towards the 'end' of the process in this instance contradicting, e.g., Big Blue Project (2002) and other IL models that place appreciating a gap in knowledge as only at the start of the research process. It has also come about via discussion and collaboration rather than working alone emphasising the importance of the social constructivist aspect of becoming information literate. Furthermore, it is argued that the asynchronous nature of Blackboard Discussion Board, enables students to read and make a considered reply thereby creating 'cognitive space' (Garrison et al, 2003) both for the reading and the reply to occur. This is significantly different to the face-to-face setting for two reasons, one: there is a complete record of the 'conversation' which is not possible in the immediacy of the face-to-face setting for students to read and re-read and two, there is more time to make a reply. This peer-to-peer pedagogical approach realised via discourse is recognised as good educational practice in constructivist approaches to learning generally (Mayes & de Freitas, 2004) and specifically noted by MacKeracher (2004) and Hepworth & Walton (2009).

In IB terms fellow students become an information source in that they exhibit *source character* e.g., "[...] allowed me to see what other people thought" and *source behaviour* is recognised, e.g., "I was writing about how he hadn't actually writ (sic) about all the actual points you were meant to evaluate in his evaluation' through their second and subsequent postings. This article asserts that this is a unique characteristic of this intervention in that OSNL enabled students to be an information source for other students to draw upon. This provided a significant addition to the process of IL teaching and learning and upholds the value of the notion of *source character* and *source behaviour* put forward by Hepworth (2004). The importance of 'participation' and the social 'negotiation of meaning', both identified by Wenger (1999) as essential

components of becoming part of a community of practice with shared, negotiated, norms can be seen to be key part of the IL intervention. This provides both a rationale and technique for becoming information literate.

Through these concurrent processes students move to a *cognitive state* of new knowledge e.g., "before I didn't know what things at the end like .ac, .org meant [...]" beyond that presented in their first posting. Again, as in the first posting, students engaged in the *behaviour* of writing a few paragraphs to post to the Discussion Board so that it, "helped decide which resources were reliable and useful and why". Finally, the *task* was closed by "posting a reply" to their colleagues. During this *task* the *affective state* appears to remain very positive throughout e.g., "I could see what everybody was getting at" and "helped by reading other people's statements" which shows that students genuinely appear to like the fact that they can see what others have written which appears to add to their own *knowledge* and promotes a reduced sense of *uncertainty*. The feeling of *uncertainty* also appeared to be reduced through familiarity with the intervention and completing the *task*. The following exemplifies this transition, "we are getting used to everything and me personally, like, it was a bit new" to a much lower degree of *uncertainty* e.g., "[...] now I have completed [...] the workshop and this study skills task I am now fully aware of how to search for online resources".

The *style state* most evident in this process is that of a positive one where students were generally motivated to complete the *task* actively fostered by reading, writing and making postings. Students reported that this was far more enjoyable, in effect it maintained a concurrent positive *affective state* than, "being lectured to" and stated that it, "gets people quite motivated to do things" showing the interconnection between *style* and *affective states*. This is supported by the views of Mayes & de Freitas (2004) and Goodyear (2001) who argue that this is the most effective e-learning intervention to deploy in a HE setting.

In writing replies to postings and the content of initial postings uphold the view of Goodyear (2001) that OSNL can promote high level cognitive processes such as *analysis*, *synthesis* and *evaluation* as described by Bloom et al (1956) and important parallel thinking skills described by Moseley et al (2004). These higher-level cognitive processes are evidenced in the written assignment. It therefore argued that this intervention has promoted 'deep learning'. This was apparent in the assessed work processes evidenced in Figure 5. It further confirms the view put forward by Walton et al (2007a) that students should be actively encouraged to be producers as well as consumers of information.

Finally, it was the role of the *tutor summary* (see figure 1) that also appeared to have some significance in the process. This OSNL component, in effect, gathered the most significant aspects of postings made by each student and were 'woven' together in a narrative where each student's contribution was acknowledged in the first person. Its positive effect on student learning is encapsulated in the following quote where a student realised: "[...] what I really need to look at when I'm evaluating websites". The *tutor summary* also

had an impact on their *affective state* e.g., it was perceived as “a nice way of being recognised” and encouraged learning motivation, e.g., “[...] quite interesting, gets you involved [...]”. Students appeared to like the fact that the *tutor summary* contained their work e.g., “it was a good way of reflecting what [we have] done”. What the *tutor summary* also provided was a tangible means of enabling students to properly reflect on their previous work e.g., “[...] interesting looking back on the work you’ve done and seeing how you have evaluated it” and also it “reflected back, I suppose it gets your brain engaged and starting to think about it again, so you’ve got more chance of remembering what you did the week before, so I suppose it, like acted as a refresher” demonstrating that this process offers a genuine means of reflection which is essential to the learning process (Race, 2001b) and encouraging *metacognition* that is fundamental to a deeper level of learning (Moseley et al, 2004). Therefore, the *tutor summary* acts as, what is termed here as, a ‘reflective bridge’ between activities capturing the most important outputs from students in a previous session and presenting them ‘woven’ (Salmon, 2002) together with tutor comments to remind students of their previous work. In so doing this provides a means of focusing students on what was learned previously before the activity and is re-iterated, and hence reinforced, within a more specific task.

In addition, it introduced a sense of writing or publishing material to a wider audience, in this case fellow students (as well as their tutors), rather than solely for the tutor. This introduces students to the idea of being part of an academic community of practice serving to take the student beyond the traditional learning experience to become producers as well as consumers of information (Walton et al, 2007a; Andretta, 2007). This is achieved by giving them an opportunity to contribute their ideas, indicating that their opinion is valued and hence giving them the confidence to participate. In effect, students not only participate but also become involved in the negotiation of meaning, regarded by Wenger (1999) as the central plank for the creation of an emergent community of practice. This article argues that because students are ‘publishing’ to a wider audience, albeit in a highly structured way, this intervention makes it more difficult for students to behave like surface or strategic learners and therefore they tend to make more considered replies in this online medium than in a face-to-face setting. In effect the *OSNL activities* created a ‘cognitive space’ for students to do so, identified by Garrison et al (2003) as a necessary part of the *OSNL* structure.

It is also of note that there was a temporal nature to the intervention in that the ‘scaffold’ used to support the learner became less evident after each activity e.g., “they all seem to be following a pattern over the weeks, I’m getting used to them”. Furthermore, the tutors were very much the ‘guides on the side’ e.g., “they were learning from one-another [...], less of us more of them” [tutor comment] which Goodyear (2001) envisaged as the way in which scaffolding should work in an online setting. This statement by the module leader could, in itself, be regarded as describing the very essence of the constructivist approach.

6. Data from written assignment (all students)

Figure 5 illustrates the processes evident at the *written assignment* stage of this intervention. It appears to be in the *written assignment* where the effect of OSNL on student learning is most readily demonstrated.

Figure 5: Written assignment: Observed cognitive states

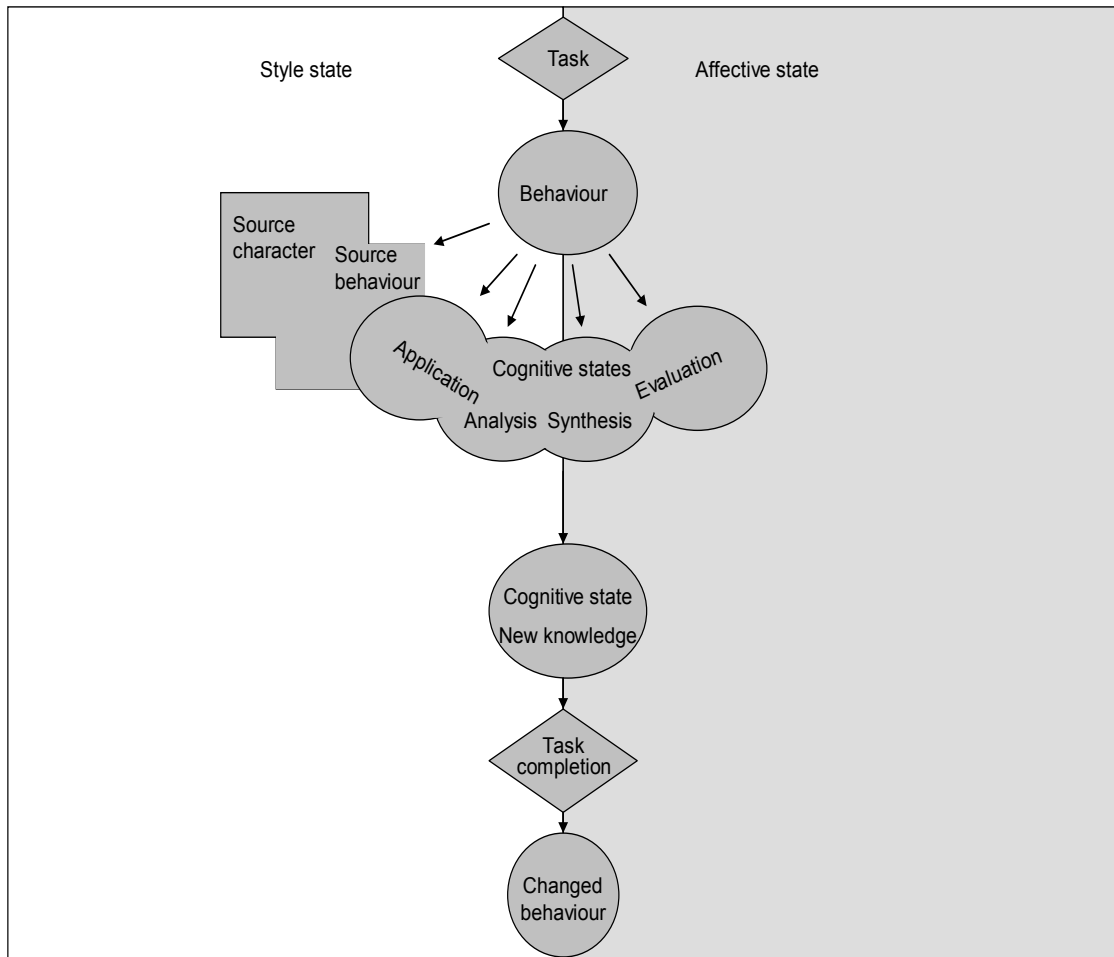


Figure 5 illustrates how the students' behaviour (the interaction with an information source), subsequent cognitive, metacognitive, new knowledge and changed behaviour are triggered by the task and underpinned by the style and affective states.

Here the *written assignment task* of finding and evaluating two books, two journal articles and two web pages caused students to engage in evaluating a range of information sources. However, it is those students who engaged in OSNL (Group A) who demonstrated the greatest deployment of the *cognitive states* of *application*, *analysis*, *synthesis* and *evaluation* in interacting with the sources they found. These states all appear to work concurrently in engaging with information sources. Following the intervention and an examination of the *cognitive state* of *application*, the module leader commented that for Group A (experimental group) students, "*the quality of resources they were using was far better than the other students in other groups*" [tutor comment]

implying that they had applied their skills to far greater effect than Groups B (intermediate group) and C (control group). Analysis of assessed reflective practice statements from all groups corroborates this view as it shows students who engaged in OSNL (Group A) were more sensitive to a range of evaluation criteria and these were applied more often in their assessed work than in the work of Groups B and C. In fact most of Group A (75%) referred to the importance of evaluating information (compared to 39% for Group B and 25% for Group C) and used three times as many evaluative words to reflect on this skill than Groups B or C (table 2).

Table 2: Relative variety of evaluation words used in assessed reflective practice statements by group.

Group A	Group B	Group C
Relevant	Reliable	Suitable
Relevance	Trustworthy (2)	Breadth
Recent	Topic related	Intended audience
Judge	Up-to-date	Published
Criterion	Unreliable	Trustworthy
Scope	Relevant	Relevant
Audience	Evaluate	Evaluating
Timeliness		
Scholarly		
Popular		
Authority		
Documentation		
Objectivity		
Published date		
Reliable (3)		
Evaluate		
Evaluating		
Critically evaluate		
Deciding		
Valid (2)		
Reputable		

Group A's ability to analyse information sources by deploying a range of IL evaluation criteria in a far more sophisticated way than Groups B and C is the most demonstrable effect that this intervention has had on students IL skills and one of the strongest findings to emerge from this study. The language used by students in their assessed reflective practice statements was the most useful way to assess IL. The evidence centres on the differences in the ways in which these groups reflected upon their ability to evaluate information. Group A students talked about taking a balanced view to information e.g. by using the words, "judge" and "deciding", "how reliable the website is, or not" and appear not to pre-judge the information sources they were evaluating. In contrast to this Groups B and C used relatively simplistic language to evaluate information e.g., "the information may not be relevant and could be unreliable"

(Group B participant) rather than engaging with the information and deciding on the degree of relevance. In addition, although a Group C participant stated that, "*I have now learnt to go into more detail*" there was no evidence of what this entailed or metacognition as a result of reflection. This article argues that this is significant because it demonstrates that the intervention with Group A enabled students to reach a high level or richer form of cognition (Bloom et al, 1956) or critical thinking (Moseley et al, 2004) or indeed 'deep learning' (Marton & Saljo, 1997) and had begun to deploy the skills which define the information literate individual (ACRL, 2000; Bruce, 1995; Bundy, 2004; Andretta; 2005, 2006, 2007). Some members of the experimental Group A, in their assessed work, showed a balanced approach to their judgements regarding information which Squires (1994, p17) defines as an 'open-mind' and argues is an essential part of learning. However, Groups B and C did not exhibit this trait. This also echoes the 'extended abstract thinking' identified by Biggs (1999, p39) as a necessary ingredient in high order thinking. In addition, this clearly demonstrates that with an appropriate theoretically and empirically grounded intervention students' IB can be changed. This assertion refutes the claim made by the 'CIBER Report' (UCL, 2008) that once learners have left compulsory education their 'bad' searching habits cannot be altered.

In parallel with the factors above it also appears that during this stage students' *affective state* was transformed from a greater to a lesser degree of *uncertainty*. At first students reported that they, "*did not know how*" to look for e-journals before the intervention but reported a lesser degree of *uncertainty* after the intervention, "*I can also use Swetswise*" again corroborating Kuhlthau (1991) and Hepworth (2004) in that when IB is successful this transition is evident.

It appears that the *style state* reported at this stage is couched in positive terms throughout e.g. a typical response was, "*this task has really helped me understand how to use it*", this adds weight to the view that learning by doing is an essential part of the learning process (Kolb et al, 1991) and corroborates the view that this should be realised via assessment (Race, 2001a).

Clearly students completed the task by submitting their *written assignment* that, in effect, allowed students to synthesise all of their skills, searching and evaluating, with a view to using the information. Indeed, the module leader observed that, in his view, those students who engaged in OSNL demonstrated changed behaviour (the single most important indicator of learning having taken place, Squires, 1194), e.g., "*we've seen students becoming more engaged, students becoming more informed, we've seen students acquiring better knowledge*" [tutor comment] and showed the most potential to change their behaviour in the future - indicated in this typical student reflection, "*I have learnt for sure [...] that the online library is the best starting point*". This observation shows that students in Group A have become better informed than those in Groups B or C. This is an essential point for practitioners of IL to note because this corroborates the view of Biggs (1999) and D'Andrea (1999) that learning interventions must be properly aligned with assessment in order for learning to occur. In the light of this

evidence this article asserts that IL models should no longer contain arguments for non-assessed programmes. Furthermore, it provides further evidence for IL practitioners that assessment is an essential ingredient in facilitating successful learning and, as a consequence, an information literate student population.

Students in Group A also differed from Groups B and C in their *cognitive state of evaluation* (Bloom et al, 1956), that is, the ways in which they reflected on their own learning. This is exemplified by the differences in statements such that Group A show a greater degree of confidence in their *new knowledge* expressed as, “*I now know how*”, and “*how to*” do certain tasks and “*how to use*” a resource whereas where as Groups B and C merely described their new knowledge in terms of quantity, “*how much*” (Group B participant) and “*plenty of sources*” (Group C participant) to use. Group A appeared to have internalised their *new knowledge*, whereas Groups B and C appeared to characterise it in an external fashion and perhaps in a surface way. Finally, and most importantly, Group A demonstrated real signs of beginning to think about evaluating the components of their learning, this is most evident in the conversation held in the focus group where students discussed the relative importance of particular IL evaluation criteria.

Student A1: “Some of them initially are important like reliability and relevance, obviously if you are going to reference something in an essay etc you need to know that the source is reliable otherwise you could be quoting anything, relevance as well, you’ve got to stick to the question or what ever you need to do needs to be relevant to the point you are making.”

Student A2: “Currency as well, to be honest, it needs to be up-to-date, opinions and things change. People thought the earth was flat but things get updated.”

Student A1: “Authority, I don’t find as important. It could be written by the government or the Football Association or something and they could make a pretty stand up point, but you could have a third year student from a university make just as good a point and just as relevant. [...] some government source could make a point which was totally irrelevant yet a student could make a totally relevant point, the authority don’t make a difference I don’t think. If it is a reliable source, if that ones covered, I don’t think authority matters, as long as it’s a reliable source.”

Whether or not one agrees with his conclusion the learner is beginning to think critically about information. This together with their assessed reflective statements shows that this intervention enabled students to reach the highest cognitive level as defined by Bloom et al (1956) and ‘deep learning’ (Marton & Saljo, 1997). Hence, this intervention, it can be argued, gives a robust mechanism for enabling students to successfully reflect on their learning and a means of articulating this skill within the IL process.

7. Discussion

This discussion intends to identify the main points of this study and their implications. This narrative also indicates how this study has contributed to knowledge in the field of IL, IB, learning and e-learning. Finally, the cognitive states and other factors identified in this study are distilled and expressed mathematically.

It was evident from this study that becoming information literate was associated with the *affective state*. Part of becoming information literate was connected with reducing uncertainty. It was evident that students exhibited a transformation from a high degree of *uncertainty* to a lower degree of *uncertainty*. This supports the work of Kuhlthau (1991) and Hepworth (2004) who observed that the affective domain is an integral part of the IB process. Hence, one objective of an IL teaching intervention should be to recognise *uncertainty* as part of the process, and be observed by students to do so, otherwise it is unlikely that successful learning or IB will occur.

Learning theory (Squires, 1994; Mayes & de Freitas, 2004; Moseley et al, 2004) and e-learning scholarship (Jonassen et al, 1995; Mayes & de Freitas, 2004) inform us that by creating the conditions observed in this study students should display a greater degree of learning e.g., as changed *behaviour* (Squires, 1994). This is born out in relation to Group A which experienced OSNL. Furthermore, it also led to a greater degree of information literacy shown as *new knowledge* regarding the use of sources such as a library catalogue or an e-journals service. This is evident in the degree of independence and choice students exhibited towards their learning, “*I can also use Swetswise to find e-journals to use for assignments*”. This is also reflected in range and order of the *cognitive states* found among the learners in Group A as a result of the intervention. The data indicated that a number of *cognitive states* are evident at this stage that of *knowledge* (process and factual), *comprehension* and *application* as defined by Bloom et al (1956) and re-iterated by Moseley et al (2004). It should be noted that the higher cognitive states of *analysis*, *synthesis* and *evaluation* do not appear to be evident with groups B and C. This article argues that it is only in the OSNL process and where work was assessed that these states become manifest and this implies that hands-on workshops to learn about information resources are insufficient in themselves to engender information literate individuals.

New behaviour should be evident and indicates that learning is in place but it does not yet constitute *changed behaviour* Squires (1994) or ‘transformation’ MacKeracher (2004) which embodies real learning. In this study it was through *task completion* i.e. the assessed work where *changed behaviour* was fully evident. This supports the view put forward by Walton (2005) that assessment is an essential component in enabling students to become information literate because it can be used to demonstrate *application* (Bloom et al, 1956). Furthermore, assessment is regarded by educationalists such as Race (2001a) as the single most important external motivator.

This study upholds the views of Kuhlthau (1991) and Hepworth (2004) that the *affective state* is a crucial factor in the IB process and also views of learning held by Biggs & Moore (1993). It also further demonstrates a link between successful learning, pedagogy, *uncertainty* and the *affective state* and *cognitive state*. The study appears to indicate that *uncertainty* diminishes as the *task* progresses and students learn more regarding the subject and in terms of their ability to interact with information i.e. their information literacy. In addition, it appears to indicate that *style state* is a further critical factor and that it is important for an intervention to foster a positive *style state*, in this case positive motivation which led to a successful outcome, that is, *new knowledge* and *task* completion.

Previous research has observed and described OSNL or online discourse as a successful means of enabling higher order learning but have not explained why this is the case. This study provides an empirically and theoretically grounded explanation of the cognitive and affective processes at work in the OSNL setting. In short, how and why OSNL works. It should be noted that these moments within the process of iteration defined as part of the OSNL process in the Pilot Study and reported in Walton et al (2007a) is a new notion within the field of e-learning. Furthermore, the high levels of cognitive skills deployed by student participants through their online discourse, demonstrates that students can synthesise their *new knowledge* to become producers as well as consumers of information. This not only serves to add weight to the work done on IL in the workplace which notes the importance of social factors in becoming information literate (echoing Lloyd, 2007) but also initiates the transferable skills students will need for active participation in a workplace community of practice. It also demonstrates how the notion of community of practice (Wenger, 1999; Mayes & de Freitas, 2004) can assist in the learning process. This aspect of IL is understated in IL models and rarely exploited in IL teaching and learning settings. It also serves to refute the assertions made by the SCONUL IL model (1999) that these high level cognitive skills of *synthesis*, where *new knowledge* is created, are purely postgraduate skills.

It is the view here that, in this study, OSNL activities appear to, at the very least, mitigate 'surface learning', as illustrated in the content of student online postings and their assessed reflective practice statements, and in some instances prevent this happening at all. It is argued that IL practitioners should not only adopt this form of learning for the IL stage of 'evaluating information' but should also consider assessing the discourse itself.

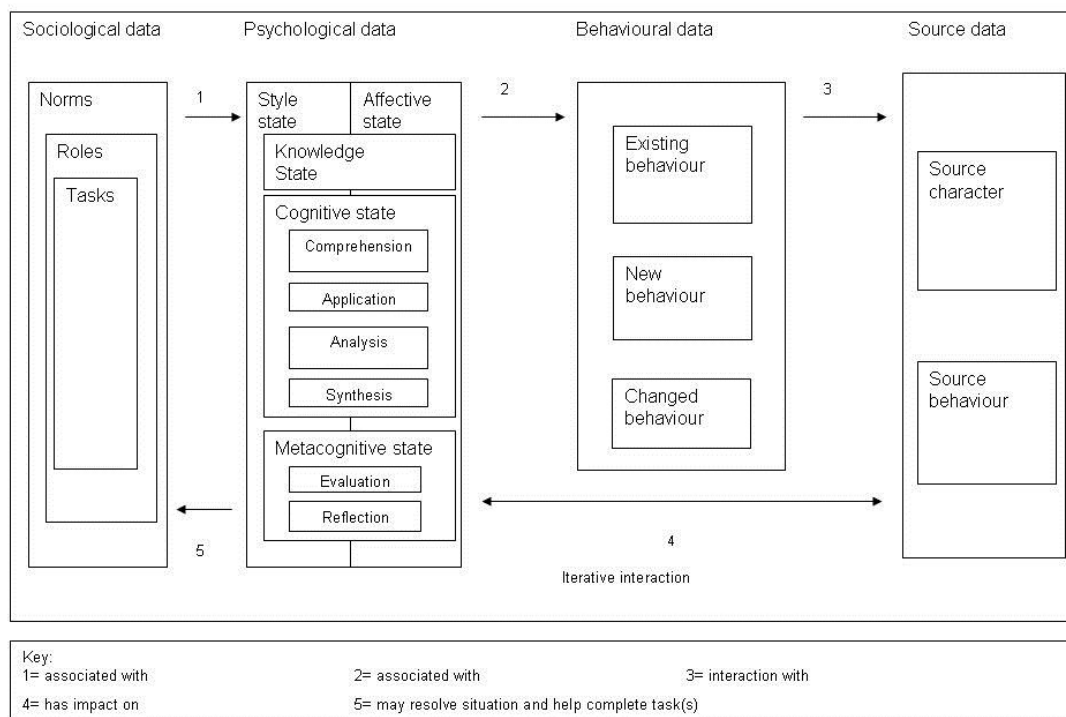
It is argued that the OSNL model is, in essence, a generic framework for carrying out this type of learning and could be carried on any platform (Walton 2009), such as Blackboard or Moodle. This is particularly useful given the increasing plethora of online social media tools (Beetham & Sharpe, 2007) and other Web 2.0 developments (Godwin & Parker, 2008).

It should be noted that the findings from this study strongly indicate that students' behaviour changed as a result of this intervention (as evidenced in participants' statements which mentioned how they had changed the way they regard web based information and also in their assessed work) which serves

to refute the claim made by the 'CIBER Report' (UCL, 2008) that students information behaviours cannot be altered once they leave compulsory education. This has important implications for the information profession because the 'CIBER Report' (UCL, 2008) is one of the few documents to enter the consciousness of the popular media in the UK, e.g., see Reisz (2008) and may be used by the UK Government to inform policy and funding regarding information services in HE.

The findings from the study add to Hepworth's IB model (Hepworth, 2004) in a number of significant ways, see figure 6 below. In particular, the study has served to further articulate the *cognitive state* and has shown that Bloom's taxonomy (Bloom et al, 1956) and Moseley et al's definition of metacognition (Moseley et al, 2004) are especially useful in this respect.

Figure 6: Hepworth & Walton's model of information literacy behaviour



Here tasks, roles and norms lead to information behaviour and interaction with sources. This process is associated with different psychological states that have an impact on information behaviour and is affected by the information seeking context. In this case, the latter includes the teaching and learning intervention and the character and behaviour of the sources with which they interact. This led to *changed behaviour*, the application of thinking skills (cognitive states), *metacognition*, a *new knowledge state* and the completion of the information literacy task. *Style state* and *affective state* were also shown to play a key role in the learning process.

This study indicates that when students are given a *task* to complete together in an online setting they exhibit deeper learning at the end of the process

evidenced in their assessed work. This study indicates that students can learn a great deal from discourse with one another and perhaps learn as much from each other as from a tutor. The findings, from student comments on the face-to-face workshop, give significant weight to the assertion that in designing IL learning and teaching interventions information practitioners should look to move away from the more traditional hands-on individually focused workshop interventions to those which are group orientated and problem-based where the practitioner guides, rather than leads, the process. Nevertheless, the popularity of the student-led rather than the teacher-led mode of teaching is likely to vary depending on the previous experience and expectations and possibly the learning style of the learner.

8. Mathematical visualisation of information literacy learning

The cognitive components themselves provide the basis for identifying a potential set of formulae for representing the teaching and learning intervention (shown below). From the discussion above it can be seen that at each stage, via task completion, students gain some new knowledge. The level of knowledge gained appears to be directly affected by behaviour, the presence of cognitive and metacognitive states which are themselves affected overall by the engagement, or otherwise, of the style state. The style state here relates primarily to the motivation of the learner. The limiting factor here appears to be the affective state, in other words the greater degree of uncertainty experienced by students the less the degree of knowledge learnt. Hence, style state may act as a multiplier to knowledge whilst affective state (expressed in terms of uncertainty) may act as a limiting factor. Therefore, in the formulae shown below knowledge is represented as the sum of the cognitive and metacognitive states, multiplied by style state and then divided by the affective state. It is envisaged that measures for the cognitive components be expressed by positive integers only. Finally, the source is also represented both in character and behaviour. It is envisaged that, in this case, measures might be expressed on a continuum from positive to negative (to reflect positive or negative feelings towards the functionality of an interface or the accessibility of information within the source or the extent of discourse between tutor and student or student and student). By taking this approach for these identified behavioural, cognitive and source components, a basis for measuring the effectiveness of IL teaching and learning interventions more effectively may be possible. The formula for each component of the intervention is illustrated below.

1. Task: Face-to-face intervention

$$K_1 = B + \frac{(C_{comp} + C_{app} + C_{ana} + M_{cog})S_s + (S_b + S_c)}{A_s}$$

2. Task: OSNL first posting

$$K_2 = B + \frac{(C_{comp} + C_{ana} + M_{cog})S_s + (S_b + S_c)}{A_s}$$

A_s

3. Task: OSNL second posting

$$K_3 = B + \frac{(C_q + C_{ana} + M_{cog})S_s + (S_b + S_c)}{A_s}$$

4. Task: Written assessment

$$K_4 = B + \frac{(C_{comp} + C_{app} + C_{ana} + C_{syn} + C_{eval} + M_{cog})S_s + (S_b + S_c)}{A_s}$$

Sum of all formulae

$$\Sigma_K \equiv B_c = K_1 + K_2 + K_3 + K_4$$

Key

A_s = Affective state

B = Behaviour

B_c = Changed behaviour

C_{ana} = Cognitive state, analysis

C_{app} = Cognitive state, application

C_{comp} = Cognitive state, comprehension

C_{eval} = Cognitive state, evaluation

C_q = Cognitive questioning state

C_{syn} = Cognitive state, synthesis

K_x = Knowledge state

S_b = Source behaviour

S_c = Source character

Σ_K = Final knowledge state

M_{cog} = Metacognitive state

S_s = Style state

9. Conclusion

The study here has highlighted a number of important issues surrounding the cognitive and conative aspects of information literacy and the wider application of this pedagogic design. However, whilst this study is ecologically valid in that the intervention was applied in a real context to a legitimate sample of students attending a Level 1 Sport & Exercise Module at Staffordshire University care should be taken when extrapolating these results to other students and settings.

The study highlights the importance of a positive *affective state* in facilitating successful IB and in satisfying the designated learning outcomes of the intervention. It also shows that the *affective state* was not static and that students appeared to exhibit a transformation from a high degree of *uncertainty* to a lower degree of *uncertainty*. The intervention appears to fulfil

these goals. Indeed, in creating the conditions observed students appeared to display changed *behaviour* that is, a greater degree of new knowledge in the form of information literacy skills. Their behaviour appeared to be transformed particularly in the ways in which they intended engaging with web-based information in the future. As mentioned above this refutes the claim made by the 'CIBER Report' (UCL, 2008) that student's information behaviours cannot be altered once they leave compulsory education. However, additional data on long-term impact of the intervention would be required to see whether or not this was the case.

The data shows that a number of *cognitive states* (knowledge and application) are evident at the face-to-face stage; however, the higher cognitive states of *analysis*, *synthesis* and *evaluation* appear to be most evident for those students who experienced the OSNL process. These higher states are manifest in the assessed work but not to the same extent as for those who experienced OSNL. The role of the *tutor summary* is significant here in that it not only provides a 'reflective bridge' between activities but also gives a sense of recognition to students by 'publishing' their input to the wider group. This implies that hands-on workshops to learn about information resources are insufficient in themselves to engender information literate individuals.

Task completion via the assessed work indicates *changed behaviour* and implies that assessment is an essential component in facilitating deep learning and enabling students to become information literate.

The data shows a link between successful learning, pedagogy, the *affective state* and the *cognitive state of uncertainty*. *Uncertainty* diminishes as the *task* progresses and students learn more. Furthermore, *style state* also appears to be critical factor and the importance of *task* in maintaining a positive *style state* leading to *new knowledge* and *task* completion shows the complex inter-relation of these factors in a learning and teaching intervention.

Not only does this study show the complex inter-relation of cognitive, affective and conative factors but it also furnishes theoretically and empirically grounded explanation of these processes at work in the OSNL setting unavailable hitherto. Hence, it is argued that this study provides a platform independent, generic framework for carrying out this type of online collaborative activity that is particularly useful as social media tools continue to evolve rapidly.

The implications for the role of tutors and practitioners are significant in that all should examine the possibility of adopting a more group orientated and problem-based approach where tutors and practitioners alike guide, rather than lead the learning and teaching process.

With regard to existing models of information literacy it has been demonstrated that social factors involved in learning are understated and rarely exploited in IL teaching and learning settings. Furthermore, it has been shown that first year students demonstrated higher order learning and hence

refutes the claim of the SCONUL (1999) IL model that these are purely postgraduate skills.

Finally, the cognitive components identified here provide a potential set of formulae not only for representing the teaching and learning intervention but also for more focused measurement of its impact.

It is argued that these factors together demonstrate that this highly student centred and constructivist intervention as recommended by Goodyear (2001) and JISC (2004) can deliver successful learning in the form of new knowledge that is manifest in the *written assignment* data discussed here. This data shows that students exploited the range of resources that they learned about in this *face-to-face workshop* and found appropriate information. This also has significant implications for a more complete understanding of IB and the cognitive psychological states associated with it. It is argued here that it is essential to disaggregate the *cognitive states* discussed above, by using Bloom et al (1956) and drawing on metacognitive models identified by Moseley et al (2004), in order to properly recognise their significance when examining individuals' IB and enabling people to become information literate.

Hence, the effective gaining of new knowledge by students and the resultant change in behaviour noted in this study was only maximised when all components of the formula were present. When delivering IL learning and teaching interventions this may be achieved by integrating sound pedagogical practice, incorporating knowledge from e-learning scholarship and drawing upon information behaviour research.

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