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Representing search tasks in an information use environment: A case of English primary schools

Abstract

Purpose: To design effective task-responsive search systems, sufficient understanding of users' tasks must be gained and their characteristics described. Although existing multi-dimensional task schemes can be used to describe users' search and work tasks, they do not take into account the information use environment that contextualises the task.

Design/methodology/approach: With a focus on English primary schools, in four stages a multi-dimensional task scheme was developed that distinguishes between task characteristics generic to all environments, and those that are specific to schools. In stage one, a provisional scheme was developed based upon existing literature. In the next two stages, through interviews with teachers and observations of school children, the provisional scheme was populated and revised. In stage four, whether search tasks with the same information use can be distinguished by their characteristics was examined.

Findings: Ten generic characteristics were identified (Nature of work task, Search task originator, Search task flexibility, Search task doer, Search task necessity, Task output, Search goal, Stage in work task, Resources, Information use) and four characteristics specific to primary schools (Curricular area, Use in curricular area, Planning, Location). For the different information uses some characteristics are more typical than others.

Practical implications: The resulting scheme, based on children's real-life information-seeking, should be used in the design and evaluation of search systems and digital libraries that support school children. More generally the scheme can also be used in other environments.

Originality/value: This is the first study to develop a multi-dimensional task scheme that encompasses the information use environment.

Introduction

Historically, search systems have been designed to respond to the topic of a search query; however, people often issue queries to accomplish specific tasks i.e. "a particular item of work" in which they are engaged (Byström and Hansen, 2005, p. 1051). At present, developing systems that respond effectively to the broader task (rather than just to queries) remains an unresolved problem (He and Yilmaz, 2017). In part, this is because developing effective task-responsive systems requires the comprehensive capture and understanding of users' tasks. However, despite significant work completed to date (Kim and Soergel, 2006; Li and Belkin, 2008; Xie, 2009), we still do not have a prescriptive characterisation of tasks that could be used in developing requirements for task-based search systems.

In this research study, we put tasks 'under the microscope', restricting our analysis to tasks performed by *school children* in an *educational setting*. Our premise is in keeping with Taylor (1991, p. 233) who argued that different groups of people, such as engineers and doctors, operate in

different Information Use Environments (IUEs) such that users within the IUE have "*different information needs and uses, varying types of problems, and significant differences between what each regards as information and accepts as problem resolution*." In related work, it was found that five aspects of the school environment (the national curriculum, best practice, different skills of children and teachers, keeping children safe, and limited time and resource) influenced how and why children search for information, and that within this environment there were twelve uses of information (Authors; 2019b). In this paper, using the same dataset, we examine how the IUE influences the characteristics of a task; "*a distinctive mark, trait, or feature that may serve for identification*" (OED, 2019).

Current search task representation schemes are either generic and do not consider the particular environment within which the search takes place and the influence this has on a task (Kim & Soergel, 2006; Li & Belkin, 2008), or they consider the influence of the environment on the same characteristic (Xie, 2009). The overall objective for this study was to develop an approach for representing search tasks that originate within a particular IUE – primary schools. Search for school work may be conducted in another location (e.g. home or library), but importantly the IUE is where the information is used and where the value is given to information (Taylor, 1991). To meet the objective of this study, we addressed two research questions (RQ1) "What are the characteristics of primary school search tasks?" and (RQ2) "Can search tasks with the same information use be distinguished by their characteristics?". The research resulted in a novel representation scheme to describe the different characteristics of search tasks that may be generic to all environments and also those that are specific to one particular IUE: English primary schools (equivalent to elementary school in US with children age 4-11). Then based on analysis of 114 tasks identified from this study, typical characteristics of the tasks for different information uses were identified. In the next section, we examine the prior literature and identify some of the controversies regarding tasks, and motivations for our research questions. We then describe our four-stage research design, describing first the methods used followed by the findings of our study. Finally, we discuss the resulting scheme and its potential for use.

Previous Work

Conceptualisation of task and search task

Search is rarely carried out for its own sake and is a dynamic process that is part of a larger process of decision making and problem solving (Rouse and Rouse, 1984). Work tasks, the *"separable parts of a person's duties to her/his employer"* (Byström and Hansen, 2005, p. 1053) are considered an important motivator of search. Tasks are hierarchical and within a work task, there can be many information tasks, one of which might be a search task, where information is looked for in response to an information need to fulfil, or partially fulfil, a work task. In schools a unit of work is "*a coherent body of teaching/learning material usually focused on one specific topic or subject*" (Dictionary of Education, 2016) and can be considered as conceptually similar to work tasks. For example, a unit, such as learning about rainforest creatures, can be considered a work task and a search task could be to find out what anacondas eat. A search task could be completed by submitting one or more queries to a search engine.

Children's search tasks

In many of the studies that examine children's use of search systems, information-seeking is conducted out of 'normal' contexts. For example, in Jochmann-Mannak et al.'s (2010) study children were taken out of the classroom to search on their own. Furthermore, when researchers have designed search tasks they frequently do so to investigate particular characteristics or to stimulate activity but the actual search tasks are rarely derived from real-life. For example, Druin et al. (2009) gave children a multi-step task of "*Which day of the week will the Vice- President's birthday be on next year?".* Whether these researcher-designed tasks resemble school tasks is uncertain, and perhaps tellingly none of the children in Druin et al.'s (2009) study were able to complete the task. Interestingly, in a broader study of workplace information-seeking, Saastamoinen and Järvelin (2017) find that simulated work tasks and search tasks do not resemble real-life work tasks and search tasks. Another problem in identifying children's real-life search tasks is that although there have been a number of studies of children completing research assignments for school work (for example Cole *et al.*, 2013), these studies tend not describe the actual search tasks. Hence, we lack an understanding of what school children do and whether the systems developed for school children actually meet their needs.

An effective task representation scheme would fully characterise and distinguish between different types of tasks; however, such a representation is lacking for children's search tasks in general and their school search tasks in particular. Descriptions are often poor with many search tasks described with, at best, three characteristics. For example, many studies use Bilal's (2002) categorisation of goal, complexity and origination, but do not include any characteristics of the underlying work tasks (e.g., whether they are routine, typical or unusual), nor at what stage in the work task the search task occurs. That so few characteristics are described is problematic, especially when compared with the task schemes described in the next section, as search tasks are multi-faceted and more than one characteristic could be responsible for a study's finding (Freund and Wildemuth, 2014). Coupled with this, there are no agreed definitions and operationalised standards. For example, fact-based search tasks may have "*a yes/no answer*" (Kammerer and Bohnacker, 2012, p. 185) or are "*usually simple, certain, and uncomplicated in nature. Such tasks have a target answer that may be a date, a location of an address, a lifespan of an animal, and the like*" (Bilal and Kirby, 2002, p. 656). Similar to Bilal and Kirby's (2002) definition of fact-based tasks, a Verificative Information Need "*concerns the searching for a specific piece of information (fact-oriented)*" (Borlund, 2016, p. 315) and a closed task is to "*find a fact* " (Marchionini, 1989, p. 57). In all these examples, factual information must be found but the naming of the characteristic varies and so do the definitions. While in part this is a reflection of the range and complexity of search tasks, this lack of consistency is problematic because it makes it difficult to compare findings across studies (Kim and Soergel, 2006), and so our understanding of search tasks is fragmented.

Describing tasks

Hackman (1969) suggests tasks can be described in four ways: (1) "*task qua task*" refers to the objective properties of the task; (2) "*task as behaviour requirement*" refers to what the task doer should do; (3) "*task as behaviour description*" refers to what the task doer actually does; and (4) "*task as ability requirement*" refers to the abilities the task doer needs to have to successfully complete the task.

Tasks can also be described subjectively (i.e., how they are perceived by the task performer) or objectively (i.e., independent of the task performer) (Hackman, 1969; Byström and Hansen, 2005). This separates the prescribed task that emerges from the work place (or in the case of children in an educational setting, from the prescribed curriculum) and how those children eventually handle the task. In an educational context, the 'same' objective task is often assigned to multiple people who may in turn perceive the task differently (Hackman, 1969; Limberg, 1999). In this research, the "*task qua task*" approach was taken and the objective properties of a task independent of how it may be perceived is described. While recognising that the subjective aspect of a task is important, this relates more to the performance of the children than the task per se.

Three key schemes that have been developed to describe tasks are Li & Belkin's (2008) "*faceted classification of task*", Kim & Soergel's (2006) "*list of task characteristics*", and Xie's (2009) "*dimensions of tasks*". These are described next.

Derived from a literature review, Li & Belkin (2008) incorporate work tasks, information-seeking tasks and search tasks into a single scheme. They classify them using the same set of eighteen facets/sub-facets and, where possible, values. They find that there are both generic facets of task (source, doer, time, process, product and goal) and common attributes of task (characteristics and user's perception). Using this classification scheme, Li (2009) examines both inter-relationships and intra-relationships of search task and work task, concluding that a work task influences search task, and that the facets of search task most affected are length of time, and both objective and subjective task complexity. Li & Belkin (2010) also use the scheme to investigate the relationship between work tasks and search behaviour. They find that there are different search tasks for different work tasks, and that both work task and search task influence search behaviour.

Similarly, deriving their scheme from a review of the research literature, Kim & Soergel (2006) identify twenty-eight characteristics and a multitude of corresponding variables that have been used to study task. Building on the framework developed by Hackman (1969), they arrange task characteristics under four categories: intrinsic task characteristics, extrinsic task characteristics, task performer, and relationship between task and performer. However, they do not distiguish between work and search task. They identify that stage, complexity, analysability and determinancy, interdependence, and scope of task are the characteristics most associated with changes of information behaviour.

In two settings (corporate and academic), Xie (2009) empirically investigated the dimensions of a task that are important in the search process. Xie (2009) identified three key dimensions for work task: nature, stage and timeframe, and three key dimensions for search task: origination, types and flexibility. During the search process planning, use of strategies and changes in goal are influenced by different combinations of these dimensions.

Although each of the schemes described above provides a way to describe tasks, and the important relationships among task characteristics, it is doubtful that they could be used wholesale to describe school children' search tasks. Both Li & Belkin (2008) and Kim & Soergel's (2006) schemes incorporate the many categorisations of tasks from the research literature making them difficult to use, and it is unclear which characteristics are important to particular environments, and even to what extent the schemes can be used to describe search tasks as they occur in real-life settings (as opposed to tasks developed in lab studies). Xie's (2009) dimensions are more succinct and are

derived from real-life settings, but whether the same dimensions would be applicable to a school children's learning environment remains unclear.

A further issue is that while prior multi-dimensional schemes can be used to describe individual search tasks, there is no easy way to describe search tasks in different settings; in other words, what are primary school search tasks as opposed to, for example, an engineer's search tasks? He & Yilmaz (2017) found when trying to identify the co-occurrence of characteristics in real-life tasks using Li & Belkin's (2008) facets that the characteristics of seemingly similar tasks can vary considerably. In related work (, 2019b), we identified twelve distinct uses of information that occur in English primary schools. The same classes of information use were described by teachers in all the primary school year groups, and although prior studies have reported similar uses (Morrison, Pirolli and Card, 2001; e.g. Freund, 2008; Toze, 2014), the particular combination of information uses is probably linked to the learning environment and the age of the children. In this study, we investigated whether search tasks with the same information use can be distinguished by their characteristics (RQ2), as if they did then information use could be a way to describe the set of search tasks within an IUE.

Research Design and Methods

In related work, we investigated the way the IUE influences how and why children search for information at school (Authors; 2019b). In this paper, the same dataset is used to investigate the characteristics of school children's search tasks following the four stages shown in Table 1.

[insert Table 1 here]

Table 1: Overview of research design

Stage 1: Developing a provisional search task representation scheme

Initially schemes that had been used to describe adult search tasks were assessed for use as a suitable framework (Kim and Soergel, 2006; Li and Belkin, 2008; Xie, 2009). However, as previously discussed, none of these schemes were considered sufficient. Because we used a particular group (primary school children) in a particular setting (the learning environment) we opted not to use one of the existing schemes, which were generic and created in multiple adult environments, as the starting point. Our approach was to begin with a 'clean slate' by examining the research on children in various settings. To guide this analysis, we used the set of core questions identified by Li & Belkin (2008, p.1833) to extract from the research literature what is known about children's search tasks in any environment. At this stage, the IUE could not be taken into consideration as so few studies document children's real-life school tasks.

Stage 2. Developing the scheme for the primary school IUE

To develop the scheme for a specific IUE, search tasks in primary school and their characteristics were identified. To uncover the range of tasks completed by children in their learning environment, interviews could either be conducted across a range of schools or a range of teachers within a single school. As there has been no prior research into how school differences affect search, what factors would lead one school to have different types of search tasks from another is not known. However, in terms of what might affect search within a school, research in the field suggests that children of

different ages have different search practices (Marchionini, 1989; Gossen, Hempel and Nürnberger, 2013) and this could be indicative of different search tasks. Therefore it was decided to interview ten teachers from a single school, from now on referred to as West School. Two teachers who specialised in computing, and one teacher from each of the seven primary school year-groups were purposefully recruited. One teacher asked if a colleague could join the interview, resulting in ten interviews altogether. Using this sample accounted for the anticipated variation between the year groups. Sampling was therefore based on *a priori maximal variation* to account for heterogeneity (Patton, 2015). Interviews were conducted individually with the exception when two interviewees requested a joint interview.

In each interview, teachers were asked to reflect over the academic year (September 2014 to July 2015) and to describe situations in which children might search for information. To aid teachers in their descriptions of tasks, a set of questions based on Li & Belkin (2008, p.1833) was used as an interview guide. The wording of the questions was adapted to make them more familiar for teachers and less LIS discipline-centric (see Table 2). The intent of this approach was to extract from teachers all the characteristics of primary school search tasks. At the end of each interview, each teacher was asked if the other teachers who taught in the same year group would answer the questions differently (none thought they would). This was anticipated as the curriculum is prescribed.

[Insert Table 2 here]

Table 2: Interview guide / Li & Belkin's (2008) questions

The nine interviews with ten teachers resulted in five hours and thirty-eight minutes of discussion. Qualitative Content Analysis (Zhang and Wildemuth, 2016) was used to analyse the interview data. The coding scheme was developed from the provisional task representation scheme (stage 1), which was then modified based on teachers' responses. We operationalised each search task as the specification of an information requirement as stated by the teacher, resulting in the identification of 105 search tasks. Each search task was differentiated by a brief portrayal of the information requirement. This information requirement was then treated as a label for the task. Following this, all characteristics of the task were identified. The teacher's descriptions of each search task could be brief but often the characteristics could still be inferred. For example, one of the specialist Computing teachers stated that "*the majority of the time the children are working with a partner, and only because there are not enough computers for one each*". From this it was inferred that in the Computing class children will normally work in pairs, even though this was not stated for each of the search tasks described. However, for some search tasks not all of the characteristics could be identified.

At the end of stage 2, all 105 search tasks described by teachers were documented in a representation scheme that was developed initially based on the research literature and then adapted for the primary school IUE. Then which parts of the representation scheme were generic and could be applied to any IUE, and which were likely to be specific to primary schools was considered.

Stage 3. Validating the task scheme

To test the representation scheme that emerged from stage 2, data collected from two previous studies were re-used (Authors, 2015; Authors, 2019a). Three classes were observed. Two of the class observations (30 children aged 8-9), collected on 26 June 2012 during two consecutive Computing lessons, were from the same Stage 2 school (referred to as West School).. The third observation (25 children aged 10-11), collected on 12th June 2014, were from another school (referred to as East School). Both schools are located in the north of England, are large primaries and are rated "good" by Ofsted, the English school inspector (www.gov.uk/government/organisations/ofsted). The majority of pupils in both schools are from White British heritage and the proportion of pupils with special educational needs is above national average. The schools differ in their catchment areas; the proportion of pupils at East School deemed disadvantaged is well above average but at West School well below average.

The three lessons were audio-recorded. In addition, the search sessions of six pairs from West School and eight individuals from East School were screen captured using Morae and Camtasia screen recording software. The following steps were taken to analyse the data. (1) The search tasks were isolated and identified, and these originated either from the teacher's comments, or from observations of the children who created their own search tasks. (2) Using the scheme developed in stage 2, each of those search tasks was mapped to the task questions . (3) Different characteristics of each task were identified. Techniques used to identify characteristics varied. Identifying some characteristics (such as origination) was straightforward and easily observable. Other elements could be identified but required appreciable inspection. For example, some of the information uses had to be carefully determined from the queries and the children's conversations. For example, when a pair of children from West School said "let's check it in Bing" this was considered to be to a verify information use.

Stage 4: Grouping tasks by information use

Overall, 114 search tasks and their characteristics were identified in stages 2 (105 search tasks) and 3 (9 search tasks). The search tasks were then grouped according to information use and typical characteristics that helped further distinguish the tasks; for example, whether information use classed as "to define" originated from children or the teachers. Typical characteristics were identified in large part according to the count of occurrences of a particular characteristic, but also whether a teacher had described a characteristic as typical and often occurring.

Ethics

The research was reviewed and approved by the University's Research Ethics Committee. The primary school leadership team gave formal approval for the data collection in stages 2 and 3. In addition, informed consent was obtained from all teachers and children who participated in the studies. Particular care was taken to ensure that children understood and assented to the studies: firstly letters were sent home to parents, secondly class teachers and the first author explained the study in person to the children, and thirdly it was made clear that they could withdraw at any stage. To ensure confidentiality of our participants, all data are anonymised.

Results

In the following sections the findings from each of the four research stages are presented.

Stage 1: Developing a provisional search task representation scheme

In stage 1, a provisional representation scheme was derived from previous literature.

"Where is this task from?"

There are four ways to answer this question: What is the work task that motivates the search task, what is the nature of the task, from whom does the search task originate and how flexible is it.

Children are taught in *units* of work: *"a coherent body of teaching / learning material usually focused on one specific topic or subject"* (Dictionary of Education, 2016). These could be considered conceptually equivalent to work tasks. However, there are many units of work and to date there has been no attempt to differentiate children's work units in relation to search tasks. In the more general field, there is no categorisation that can be used across different domains either (Author, 2011). Another approach may be to consider the nature of the work task, i.e. if the task is typical, routine or unusual (Xie, 2009).

Origination can be considered at task initiation (Gross, 2006; Limberg, 2007) or how it changes over time (Shenton and Dixon, 2004; Lundh, 2010). It is likely that both ways of considering origination will be needed. For origination at initiation, Li & Belkin's categorisation of internally-generated, externally-assigned and generated in collaboration could be employed. Xie (2009) categorises the flexibility of search tasks (very flexible, flexible, inflexible), and this could be used to determine how origination changes over time. However, this question may be best answered using Shenton & Dixon's (2004) classification of how much flexibility teachers give children when select topics for their homework assignments.

"Who carries it out?"

Studies of real-life tasks indicate that children commonly search individually, in pairs and in groups (Crow, 2011), and this is similarly characterised by Li & Belkin (2008) and Kim & Soergel (2006).

"How long does this task last?"

Studies where children will be using search engines in real-life tend to be for research assignments, and these assignments often take place over multiple lessons (e.g. Cole *et al.*, 2013). In experimental studies, the search tasks are usually conducted in a single lesson. Li and Belkin's (2008) length of task (short term / long term) could be employed to describe duration.

"What is it about (topic or content)?"

The topics of children's search have been categorised in many studies (for example Duarte Torres, Weber and Hiemstra, 2014; Vanderschantz, Hinze and Cunningham, 2014). However, given that the number of topics is large it is questionable how useful this categorisation is for describing tasks. Multidimensional schemes do not consider topic as what is being searched for is potentially unlimited (Li & Belkin, 2008).

"How should this task be completed?"

There are three ways to answer this question: what information is used for, stage of task and the resources used.

Both Limberg (1999) and Heinström and Sormunen (2015) have examined the different ways information is used during research assignments. Lundh and Limberg (2012) have also examined the different ways pictures are used. Taking a broader approach that considers all uses of information in primary schools, we previously identified twelve information uses: to orient, to extend, to make sense, to illustrate, to decorate, to verify, to navigate, to define, to get instruction, to entertain, as precise data, no clear use (Authors, 2019b).

That search occurs in stages for children's work tasks has long been recognised (Kuhlthau, 2004). Xie (2009) considers the stage of a search from the task performer's point of view and determines this based on what the task performer is focused on.. This categorisation is based on the individual so cannot be used here. By contrast Li & Belkin (2008) categorisation of stage is based on when the search task occurs in the work task and is more pragmatic.

As part of their study Madden, Ford & Miller (2007) asked secondary-age children what resources they used for homework assignments. It is thought likely that a similar set of resources would be used by primary school children.

"What are its products?"

There are three ways to answer this question: output, outcome and search goal.

Children's search tasks may result in outcomes (what has been learnt) as well as outputs (the physical product) (Tanni and Sormunen, 2008). These have yet to be categorised for children's search tasks. As cognition is individual and in the head, outcomes will probably be difficult to identify.

It is common to categorise the goal of children's search tasks (for example Bilal, 2002). However, there is considerable duplication of goal types. In the more general literature, Author (2011) argues that search tasks can be categorised as either specific item (particular information is looked for) or general topical (information on a topic is looked for but nothing specific) and this may be a more parsimonious way to categorise children's search task goals.

Summary

Using the research literature, a provisional representation scheme was developed that incorporates what is thought important to consider when describing search tasks and what is already known about children's search (Table 3). However, there are many gaps and this scheme is not specific to the IUE.

Stage 2: Developing the scheme for the primary school IUE

In stage 2, the stage 1 scheme was adapted for the primary school IUE, and populated with the tasks teachers described. A summary of search task characteristics identified in stage 2 is given in the Appendix.

What is the nature of the motivating work task?

The majority of the search tasks were for typical work tasks: although children learnt new topics for different subjects, how the topics were taught was familiar. Teachers also described unusual and routine work tasks. For example, the Y5 teachers described how children (aged 9-10) raised money for charity, an activity that occurred outside of usual lessons. The Foundation teacher (teachers first year of school) described how during Registration (a twice daily activity where children's attendance is recorded) the class (aged 4-5) searched for how to say "*hello*" in different languages. It is likely that the distinction between typical, routine and unusual does matter, as it is only for the routine Registration work task that a routine search task was reported.

From whom does the search task originate?

Teachers described most search tasks as originating from themselves and therefore for the children they were externally-generated. Tasks could also originate from children (i.e., internally-generated). For example, children asked questions in class that were then answered by searching the Internet. Furthermore, search tasks generated in collaboration from class discussion could mean no particular person was considered to have originated the search task (i.e., generated in collaboration). As such Li and Belkin's (2008) classification can be applied. However, as tasks could be carried out by both teachers and children (see below), to describe how tasks originate in a primary school IUE it is also necessary to describe roles (i.e. teacher, children, teacher with class).

If a search task originates from a teacher, how flexible is it?

When teachers generated search tasks for children, these tasks were designed with varying degrees of flexibility, and Xie's (2009) broad classification can be used. More specifically, teachers could give children a choice over what to research (they could choose their own topic / area of their own interest or choose between questions) but this choice could be constrained by a framework of information requirements. The degree of flexibility depended on whether the search goal was general topical or specific item. Shenton and Dixon's (2004) classification of homework (which were general topical search tasks) needs to be extended and adapted for different types of search goal.

Who carries it out?

Children searched individually, in pairs and in groups confirming Crow's (2011) classification. But, even when children nominally searched "individually" they shared information and worked together in the classroom. Li and Belkin's (2008) classification of "individual in group" more accurately describes how children searched. In addition, to support children and also because of time and resource constraints, teachers carried out children's search tasks. Therefore, teachers also do children's search tasks.

Teachers described some search tasks as compulsory, but not all search tasks needed be carried out by all children. As well, children could elect to do search tasks such as looking up the spelling of words.

How long does this task last?

Teachers described adapting and designing tasks to the time available and this depended on planning and location, rather than teachers setting search tasks with different timeframes. When teachers had planned search activities, the search tasks were mostly conducted by children. If the planned activity was conducted in class, the search goals could be general or specific. When the search tasks were given as homework, the search goals were often general. Teachers explained that this is because children have more time to search at home. For unplanned search activities, the search tasks usually had specific goals and were often in response to children's questions. These searches could be conducted in the classroom if there was time or it might be suggested that children do these searches at home.

What is it about (topic or content)?

Teachers described a wide range of search topics, for example, Animals, Africa, Climate & Weather, and Biography of a Scientist. A succinct representation of topic was not possible. However, the curricular area could be used to describe the source of a search task. Teachers described how search tasks could occur across a range of subject areas, particularly Literacy, Geography, History, Computing and Science, and also in response to events happening in the school.

How information is used depended on the curricular subject: for some subjects, such as Geography, History and Science, search systems were used to find out about the subject; for other subjects, such as Literacy and Computing, search systems were used to indirectly to learn about the subject. For example, children might search about a celebrity when learning to write a biography in Literacy.

What is information used for?

The search tasks covered all the information uses bar "to entertain" identified in related work (Authors; 2019b). Teachers did describe though that they used search technologies because it was fun.

What stage in the work task is the search task?

As well as conducting search tasks at the beginning, middle and end of work tasks, some search tasks were not specific to a particular stage. This was particularly the case for dictionary searches and searches that resulted from children's questions. This fits with Foster's Nonlinear Information Seeking Model (2004, p. 235) whereby the information seeker can use the "whole palette" to resolve information problems. "Any" needs to be added to Li & Belkin's classification.

Teachers also described how topics were used to integrate learning across different subjects, and this meant that a search task could have both a motivating work task and a uniting topic. For stage of task, a uniting topic is likely more important than motivating task because as knowledge of a topic increases this changes what is looked for and how (Vakkari, 2016).

What resources are used?

While teachers described resources listed by Madden, Ford & Miller (2007) they were more concerned with distinguishing between whether a resource was (1) a specific resource, such as a particular app, website or book or (2) a generic resource, such as any website or any book. Teachers

also described how children searched together and discussed what they knew before and after search activities, and invariably other people were always an information resource.

What is the output?

Formal writing was the most common output but the range of formal writing products was vast and included leaflets, brochures, posters, postcards, decorated texts, booklets, fact sheets / fact files, and glossaries. Teachers reported a range of other ways children presented their research beyond written documents (e.g., videos, sugar cube pyramids, fabric necklaces, cakes in the shape of Tutankhamen, and Plaster of Paris heads of Medusa).

What is the outcome?

As outcomes are particular to individuals these could not be identified from the teacher interviews, and so this question was removed.

What is the search goal?

Teachers described search tasks

The goal of the search tasks teachers described could be either specific item (where the goal is to look for particular information) or general topical (where the goal is to look for information on a topic but nothing specific). Teachers originated slightly more general topical than specific item searches, whereas children originated considerably more specific item than general topical searches. Teachers also describe doing specific item search tasks whereas children do more general topical. However, children are described doing more specific item searches as individuals.

Summary

The tasks, as expected, emerged from the curriculum. They originated mostly from teachers, but also from children and sometimes in collaboration. Tasks originating from teachers were designed with varying degrees of flexibility depending on whether the search goal was a general topic or a specific item. Teachers also designed tasks to fit the time available and adapted tasks depending on whether the search had been planned and the location of the search. Children searched individually, in pairs and in groups. Teachers also carried out the children's search tasks. Topics were used to integrate different work tasks and so a search task could fulfil more than one work task that could be at different stages of completion. What information resources were used varied but invariably people were always an information resource. Search tasks resulted in eleven information uses and in the production of a wide range of outputs. We, therefore, conclude that prior multi-dimensional schemes can only be used to describe some of the characteristics of search tasks as they occur in primary schools.

At the end of stage 2 a provisional IUE representation scheme was developed (Table 3) that was then validated in stage 3.

[Insert Table 3 here]

Table 3: Developing the provisional scheme

Stage 3: Validating the task scheme

In stage 3, the stage 2 scheme was validated using three classroom observations in two schools. We first describe the observations and then which characteristics have been confirmed are documented (Table 4).

In West School, the Computing teacher asked each of the two classes what topic they were learning about in their Science lesson and then asked them to think of three questions to which they would like to know the answer. Children suggested questions such as "*what is the longest bone*". These questions were written on the interactive whiteboard and the teacher also told both classes that if they found the answers to all three questions they could search on another question of their own choosing based on the same topic. None of the children observed in this study did this. The children worked in pairs and were free to choose their partner (except those participating in this study as they needed to work together).

In East School, the teacher displayed on the interactive whiteboard a question for the children to answer ("*There are different colour jerseys that the riders can win [in the Tour de France]. What are they for?*"). The Tour de France had already been discussed earlier that day in the school assembly (an event where the whole, or part of the, school meet for a common activity). The children searched for this information individually. However, while each child had a computer they shared information and answers, and thus often worked collaboratively. When some children found the answer the teacher then orally gave children a second search task to complete if they had finished the first task ("*Our country for the World Cup is Spain. I would like you to find out as much information about Spain and the [football] World Cup as you can. So I don't want to know about culture, I don't want to know about food, I don't want to know about the tourist industry, I want to know about the World Cup and Spain*."). Two children also conducted search tasks on polecats for their own entertainment (unknown to the teacher). As these tasks originate from the home and the information was not used for school work, we do not consider them further.

[Insert Table 4 here]

Table 4: Validation of stage 2 scheme

Using the stage 2 scheme, the observation data were mapped to the characteristics. Many of the characteristics were confirmed and codes could be applied as they were. Next the findings are aggregated across the three stages and, for simplicity in presentation, the scheme is split according to its potential for use in any IUE (Table 5), or whether it is likely to apply only to primary schools (Table 6).

[insert Table 5 here]

Table 5: Characteristics likely to be generic to all IUE

[Insert Table 6 here]

Table 6: Characteristics likely to be specific to the primary school IUE

Stage 4: Grouping task by information use

Next, we examined whether tasks for the same information uses (identified in Authors, 2019b) could be distinguished by their characteristics. For example, whether say search tasks with a "to orient" (to orient to a topic by seeking a broad and general understanding) information use are typically originated by children or by teachers. All 114 search tasks and their characteristics identified in stages 2 and 3 were entered into a spreadsheet, and grouped according to information use. For each information use, the typical characteristics (Table 7) were identified based on a count of occurrences and whether a teacher had described the characteristic as typical and often-occurring.

For each of the information uses, the characteristics for some of the tasks were non-specific and any of the characteristics described in Tables 5 and 6 could be applied. But for each information use, there were also characteristics that appeared to be typical for some task questions. For example, when the information use was "to make sense" (to bridge a gap in understanding), the search tasks were usually for typical work tasks, originated by children, optional, had specific search goals, could occur at any stage, general resources were used, and they occurred unplanned. However, who did the task (teacher / child), the outputs, the subject it was for, how the information was used to support the learning of a curricular subject, and the location (home / school) of the search varied.

In addition, for twelve of the fourteen task questions, one characteristic dominated for one or more information uses. For example, teachers typically originated search tasks with "to orient", "to extend" "to illustrate" "to decorate" "as precise data" and "no clear use" information uses but children typically originated search tasks with "to make sense" and "to define" information uses. For task output and curricular subject no characteristic dominated for any information use. This could be because the dataset is not large enough to show differences. However, as detailed in related work, teachers described the importance of not restricting children to particular outputs and that using search systems was part of their usual classroom practice (Authors, 2019b).

[insert Table 7 here]

Table 7: Typical search task characteristics for different information uses (from stage 2)

Discussion

The overall objective for this study was to develop an approach for representing search tasks that originate within an IUE using the case of English primary schools. This led to two research questions. To answer the first research question (What are the characteristics of primary school search tasks?) we developed a succinct representation scheme. We found that as well as characteristics that are generic to all IUE (Table 5), there are also characteristics specific to the primary school IUE (Table 6) that may not be present in anything but a learning environment. Together Tables 5 and 6 identify all the objective characteristics of primary school search tasks. These schemes are based on what children actually do in schools, and provide new insights on the variety of search tasks within the primary school IUE. In the Appendix we also provide examples of search tasks that have been classified this way.

We suggest that to develop task-responsive search systems it is important to distinguish between generic and specific characteristics. Existing multi-dimensional schemes (Kim and Soergel, 2006; Li and Belkin, 2008; Xie, 2009), while useful, do not differentiate task characteristics according to the IUE. Many of the characteristics we identify as generic to all IUE are found in the multi-dimensional schemes (Table 8). Although not accounted for in prior schemes, it seems reasonable to assume that information use, resources used and whether the search task needs be conducted are also important characteristics of tasks in other IUE. With regards to the specific characteristics for primary school IUEs, as could be expected these are not covered in prior schemes. Conversely, "*time length*" (Li & Belkin) and "*timeframe*" (Xie, 2009) that feature in prior multi-dimensional schemes are not directly relevant to the primary school IUE as teachers account for time by adapting the design of tasks depending on whether the search activity is planned and the location of the activity. Our findings support Taylor's (1991) argument that IUEs have different information needs and different ways of resolving problems and, therefore, that some aspects of tasks are particular to the IUE. We suggest that general purpose search systems should be designed for the generic characteristics identified in Table 5, with specific characteristics addressed through personalisation and other techniques.

[Insert Table 8 here]

Table 8: IUE characteristics compared to multi-dimensional schemes

For those developing task-based search systems and digital libraries bespoke to school children the combined representation schemes (Tables 5 and 6) can be used as a basis for designing search tasks that are realistic and reflect what school children actually do. The combined representation schemes also go beyond the usual categorisation of children's search tasks of goal, complexity and origination (Bilal, 2002) and offer a more comprehensive way of describing search tasks in schools and possibly other environments in which children search. More fully describing search tasks and using standard operationalisations will make it easier to compare findings across studies (Freund & Wildemuth, 2014).

Educating children to use technology is a concern in many national and international reports (OECD, 2015; House of Lords, 2017), and so researching children's use of search systems is an area of growing interest and study. The new representation schemes can also help to draw attention to gaps in the existing research literature. Research has often concentrated on search tasks whose information use is "to orient" or "to extend", and almost all guidance developed for school children is for research assignments (e.g., Kuiper, Volman & Terwel, 2009; Nesset, 2013). However, school children are also using search systems in far more diverse ways to solve impromptu information needs (for example, the spelling and meaning of words) (Authors, 2019b) and it is possible that in these situations school children will require different support mechanisms. We suggest that given the frequency of information uses identified in this study (Table 7), it is likely that school children will need to be taught and develop a range of search skills to effectively solve their information problems.

For our second research question (Can search tasks with the same information use be distinguished by their characteristics?), the search tasks were grouped by information use. Given that there are twelve primary school information uses the dataset is too small to identify patterns for all the information uses; however, there are indications that for some information uses the characteristics

are more typical than others (Table 7). It should not be thought that there is a direct one-to-one relationship between information use and characteristics: how people search is much messier than that. We do suggest though that information use, missing from other multi-dimensional schemes (Kim and Soergel, 2006; Li and Belkin, 2008; Xie, 2009), is a key characteristic, and a potentially fruitful way to group the varied search tasks that occur in practice in an IUE. This has implications for system design: to develop effective task-responsive systems, we propose that search systems should be tested for information use, and when studying school children for the characteristics identified as typical in Table 7.

Limitations and future work

In future work, we intend to test what we have identified here as generic task characteristics (Table 5) in other environments, and also to identify other characteristics of tasks that are specific to particular environments. Furthermore, although this study was designed to identify a range of primary school search tasks and goes beyond just describing research assignments, we recognise that to gain a full picture further research in other schools is needed. Only two schools in England participated in this study and this has implications for the transferability of the findings.

Taking a "*task qua task*" (Hackman, 1969) approach the objective characteristics of primary school children's search tasks are identified in tables 5 and 6. These tables do not include the subjective characteristics of tasks identified by Kim & Soergal (2006) and Li & Belkin (2008) as these characteristics are connected to the search task doer not the search task itself. However, this distinction is important, particularly in the primary school IUE where the same objective task is assigned to a class but experienced differently by each class member (Limberg, 1999; Heinström and Sormunen,2015). Future work could usefully establish all the subjective characteristics as they occur in primary schools, and the similarities and differences with other IUE. As technology becomes increasingly embedded into children's everyday lives (Livingstone *et al.*, 2014), the home is also an important IUE but in this study was treated as a "black box". Further studies, are needed to broaden the context to include all of children's IUEs.

Conclusions

To be able to make comparisons across studies, descriptions of tasks need to be consistent. Multi-dimensional schemes, such as Li & Belkin's (2008), provide a starting point but the findings of this study suggest that IUEs will require different representation schemes. A challenge for the research community is finding ways to describe the tasks of different IUEs in ways that (1) are meaningful for a particular IUE, and (2) allow for comparison across IUEs. We believe that our generic (Table 5) and specific (Table 6) task representation schemes will help a move in this direction. We also suggest that developing effective task-responsive systems the generic and specific characteristics of tasks should be considered, depending on the remit of system. Furthermore, search systems should be tested for different information uses.

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References

Author (2011)

Authors (2015)

Authors (2019a)

Authors (2019b)

Bilal, D. (2002) 'Children's use of the Yahooligans! Web search engine. III . Cognitive and physical behaviours on fully self-generated search tasks', *Journal of American Society for Information Science and Technology*, 53(13).

Bilal, D. and Kirby, J. (2002) 'Differences and similarities in information seeking: children and adults as Web users', *Information Processing & Management*, 38(5), pp. 649–670. doi: 10.1016/s0306-4573(01)00057-7.

Borlund, P. (2016) 'Framing of different types of information need within simulated work task situations: An empirical study in the school context', *Journal of Information Science*, 42(3), pp. 313–323. doi: 10.1177/1045389X14554132.

Byström, K. and Hansen, P. (2005) 'Conceptual framework for tasks in information studies', *Journal of the American Society for Information Science and Technology*, 56(10), pp. 1050–1061. doi: 10.1002/asi.20197.

Cole, C. *et al.* (2013) 'Seeking information for a middle school history project: The concept of implicit knowledge in the students' transition from Kuhlthau's stage 3 to stage 4', *Journal of the American Society for Information Science and Technology*, 64(3), pp. 558–573. doi: 10.1002/asi.

Crow, S. (2011) 'Exploring the experiences of upper elementary school children who are intrinsically motivated to seek information', *Research journal of the American association of school librarians*, 14, pp. 1–38.

Department for Education (2013) *The national curriculum in England: key stages 1 and 2 framework document*, *Gov.UK*. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/425601/PRIMARY_national_curriculum.pdf (Accessed: 5 February 2019).

Dictionary of Education (2016) *A brief critical dictionary of Education*. Available at: http://www.dictionaryofeducation.co.uk/ (Accessed: 25 June 2018).

Druin, A. *et al.* (2009) 'How children search the internet with keyword interfaces', *Proceedings of the 8th International Conference on Interaction Design and Children - IDC '09*. New York, New York, USA: ACM Press, p. 89. doi: 10.1145/1551788.1551804.

Duarte Torres, S., Weber, I. and Hiemstra, D. (2014) 'Analysis of search and browsing behavior of young users on the web', *ACM Transactions on the Web*, 8(2), pp. 1–54. doi: 10.1145/2555595.

Foster, A. (2004) 'A Nonlinear Model of Information-Seeking Behavior Allen', *Journal of the American Society for Information Science and Technology*, 55(3), pp. 228–237. doi: 10.1002/asi.10359.

Freund, L. (2008) *Exploiting task-document relationships to support information retrieval in the workplace*, *Unpublished Doctoral Dissertation*. University of Toronto.

Freund, L. and Wildemuth, B. M. (2014) 'Documenting and studying the use of assigned search tasks: RepAST', in *Proceedings of the American Society for Information Science and Technology*, pp. 1–4.

Gossen, T., Hempel, J. and Nürnberger, A. (2013) 'Find it if you can: Usability case study of search engines for young users', *Personal and Ubiquitous Computing*, 17(8), pp. 1593–1603. doi: 10.1007/s00779-012-0523-4.

Gross, M. (2006) *Studying children's questions: imposed and self-generated information seeking at school*. Lanham, Md.: Scarecrow Press.

Hackman, J. R. (1969) 'Toward understanding the role of tasks in behavioural research', *Acta Psychologica*, 31, pp. 97–128.

He, J. and Yilmaz, E. (2017) 'User behaviour and task characteristics: A field study of daily information behaviour', in *2017 Conference on Conference Human Information Interaction and Retrieval CHIIR '17*, pp. 67–76.

Heinström, J. and Sormunen, E. (2015) 'Students' collaborative inquiry - Relation to approaches to studying and instructional intervention', *Journal of Information Science*, 42(3), pp. 324–333. doi: 10.1177/0165551515621838.

House of Lords (2017) *Growing up with the internet*, *Parliament.uk*. Available at: https://www.publications.parliament.uk/pa/ld201617/ldselect/ldcomuni/130/13002.htm (Accessed: 2 February 2019).

Jochmann-mannak, H. *et al.* (2010) 'Children searching information on the Internet: Performance on children's interfaces compared to Google', in *Workshop on accessible search systems, SIGIR*.

Kammerer, Y. and Bohnacker, M. (2012) 'Children's Web search with Google: The effectiveness of natural language queries', in *IDC 2012*, pp. 184–187.

Kim, S. and Soergel, D. (2006) 'Selecting and measuring task characteristics as independent variables', *American Society for Information Science and Technology*, 42, pp. 1–16. doi: 10.1002/meet.14504201111.

Kuhlthau, C. (2004) *Seeking meaning: a process approach to library and information services*. 2nd edn. London: Eurospan.

Li, Y. (2009) 'Exploring the relationships between work task and search task in information search', *Journal of the American Society for Information Science*, 60(2), pp. 275–291.

Li, Y. and Belkin, N. J. (2008) 'A faceted approach to conceptualizing tasks in information seeking', *Information Processing and Management*. Elsevier Ltd, 44(6), pp. 1822–1837. doi: 10.1016/j.ipm.2008.07.005.

Li, Y. and Belkin, N. J. (2010) 'An exploration of the relationships between work task and interactive information search behavior', *Journal of the American Society for Information Science and Technology*, 61(9), pp. 1771–1789. doi: 10.1002/asi.21359.

Limberg, L. (1999) 'Three conceptions of information seeking and use', *Proceedings of the Second*

international conference on research in Information Needs, seeking and use in different contexts, pp. 1–16.

Limberg, L. (2007) 'Learning assignment as task in information seeking research', *Information Research*, 12(4), pp. 1–11.

Livingstone, S. *et al.* (2014) *Young children (0-8) and digital technology: a qualitative exploratory study - national report - UK*.

Lundh, A. (2010) 'Studying information needs as question-negotiations in an educational context: A methodological comment', *Information Research*, 15(4). Available at: http://www.informationr.net/ir/15-4/colis722.html.

Lundh, A. and Limberg, L. (2012) 'Designing by decorating: the use of pictures in primary school', *Information Research*, 17(3). Available at: http://www.informationr.net/ir/17-3/paper533.html#.Wd9HA2hSzIU.

Madden, A., Ford, N. and Miller, D. (2007) 'Information resources used by children at an English secondary school: Perceived and actual levels of usefulness', *Journal of Documentation*, 63(3), pp. 340–358. doi: 10.1108/00220410710743289.

Marchionini, G. (1989) 'Information-seeking strategies of novices using a full-text electronic encyclopedia', *Journal of the American Society for Information Science*, 40(1), pp. 54–66. doi: 10.1002/(SICI)1097-4571(198901)40:1<54::AID-ASI6>3.0.CO;2-R.

Morrison, J. B., Pirolli, P. and Card, S. K. (2001) 'A taxonomic analysis of what World Wide Web activities significantly impact people's decisions and actions', *Conference on Human Factors in Computing Systems*, pp. 163–164. doi: 10.1145/634164.634167.

OECD (2015) *Students, computers and learning: Making the connection*. Available at: doi.org/10.1787/9789264239555-en (Accessed: 15 September 2015).

OED (2019) *Characteristic*, *Oxford English Dictionary*. Available at: www.oed.com (Accessed: 5 February 2019).

Patton, Q. (2015) *Qualitative research and evaluation methods*. 4th edn. London: Sage.

Rouse, W. and Rouse, S. (1984) 'Human information seeking and design of information systems', *Information Processing & Management*, 20(1), pp. 129–138. doi: 10.1016/0306-4573(84)90044-X.

Saastamoinen, M. and Järvelin, K. (2017) 'Search task features in work tasks of varying types and complexity', *Journal of the American Society for Information Science and Technology*, 68(5), pp. 1111–1123. doi: 10.1002/asi.

Shenton, A. and Dixon, P. (2004) 'Information needs issues emerging from school assignments', *Education Libraries Journal*, 47(2), pp. 21–29.

Tanni, M. and Sormunen, E. (2008) 'A critical review of research on information behavior in assigned learning tasks', *Journal of Documentation*, 64(6), pp. 893–914. doi: 10.1108/00220410810912442.

Taylor, R. (1991) 'Information use environments', *Progress in communication sciences*, pp. 217–255.

Toms, E. G. (2011) 'Task based information searching and retrieval', in Ruthven, I. and Kelly, D. (eds) *Interactive information seeking, behaviour and retrieval*. London: Facet.

Toze, S. (2014) *Examining group process through an information behaviour lens: how student groups*

work with information to accomplish tasks, *Unpublished Doctoral Dissertation*. Dalhousie University. doi: 10.1017/CBO9781107415324.004.

Vakkari, P. (2016) 'Search as learning: A systematization based on literature', *Journal of Information Science*, 42(1), pp. 7–18. doi: 10.1177/1045389X14554132.

Vanderschantz, N., Hinze, A. and Cunningham, S. J. (2014) '"Sometimes the Internet reads the question wrong": children's search strategies & difficulties', in *Proceedings of the American Society for Information Science and Technology*, pp. 1–10.

Xie, H. (2009) 'Dimensions of tasks: influences on information-seeking and retrieving process', *Journal of Documentation*, 65(3), pp. 339–366. doi: 10.1108/00220410910952384.

Zhang, Y. and Wildemuth, B. M. (2016) 'Qualitative Analysis of Content', *Applications of social research methods to questions in information and library science*, 318. doi: 10.1002/hbm.20661.

Appendix

Characteristics	**No. tasks**	**Example search task**
What is the nature of the motivating work task?		
Routine	3	Find "x" country on a map. (Foundation)
Typical	99	Research a rainforest animal. (Y4)
Unusual	3	Where to buy "x". (Y5)
From whom does the search task originate (from the child's perspective)?		
Externally-assigned	67	Research Ancient Greece. (Y5)
Internally-generated	23	What is merguez? (Y3)
Generated in collaboration	15	What does the word coast mean? (Foundation)
If the search task originates from a teacher, how flexible is it?		
Own topic and no framework	0	-
Own topic and framework	1	Search on any topic to write an explanation. (Y6)
Own area of interest and no framework	16	Research the habitat of a creature. (Y4)
Own area of interest and framework	12	Find out about different types of weather. (Y3)
Topic specified and any true	3	Facts about Africa. (Y1)
Topic specified and framework	2	Differences between climate and weather. (Y4)
Choice of specific question	5	Choice of questions about penguins and polar Bears e.g., what do people eat when they are there; what do people wear; do children go to school there; etc (Y2)
Semi-specific information	4	Any food and any drink prices in Tesco or Asda website. (Y6)
Specific information	11	Meaning of words in the *Highwayman* poem (words selected by teacher). (Y5)
Who does the search task?		
Teacher	31	How "greeting" is said in language "x". (Foundation)
Child individually in a group	10	Spelling of a word. (Y2, Y6)
Children in a group	38	Incomplete metamorphosis. (Y5)

Characteristics		No. tasks	Example search task
Teacher or Child individually in a group		2	What is the longest python in Australia? (Y5)
Does the search task need to be completed?			
Compulsory		47	Find information about any nocturnal animal. (Y2)
Optional		14	Maths theory or code. (Y5)
Elective		14	Spelling of a word. (Y6)
Does the search task occur as part of a planned search activity?			
Planned		78	Research a minibeast. (Y4)
Unplanned		27	Answers to children's questions. (Y3)
What is the location of the search activity?			
Class		73	Look up journeys in *Kensuke's Kingdom*. (Y5)
Outside of class		30	Prepare for school trip. (Y6)
Both class and outside of class		2	Answers to children's questions. (Y3)
What is the curricular area?			
Curricular subject area	Art	3	"Find images of either a land creature, sea creature or flying creature. And find some different images to practice drawing it." (Y3)
	Computing	10	Any food and drink prices in Tesco or Asda websites. (Y6)
	Geography	15	Differences between climate and weather. (Y3)
	History	6	Mayan civilization. (Y6)
	Literacy	25	Find information on any nocturnal animal. (Y2)
	Maths	3	Maths theory or code. (Y4)
	Modern Foreign Languages	3	How to pronounce words in French. (Y3)
	Science	9	Video of plant lifecycle. (Foundation)
	Dance & Music	0	-
	Design & Technology	0	-
	Physical Education	0	-
Event		6	Picture of Rebecca Turner. (Y6)
How is the information used?			
Directly to increase knowledge of a subject area		40	Research Ancient Egypt. (Y4)
Indirectly to support learning of a subject area		24	Search on any topic to write an explanation. (Y6)
What is information used for?			
To orient		20	Research Ancient Egypt. (Y4)
To extend		22	Find out about transport in Victorian Sheffield. (Y3)
To make sense		11	How are whales like other mammals. (Y2)
To illustrate		16	For evidence that not everybody in Africa lives in a village. (Y1)
To decorate		3	Picture to decorate a science fiction story. (Y6)
To verify		2	Verification that Wolf Spiders are from all over the world, not just England. That some are deadly and poisonous. But not ones found in England. (Y2)

Characteristics	No. tasks	Example search task
To navigate	5	Refind Scientist page. (Y5)
To define	12	What is merguez. (Y3)
To get instruction	2	How to make lemonade. (Y5)
As precise data	10	Cost of a meal at a local restaurant. (Y6)
No clear use	2	Use Rightmove to understand data handling (Y3)
What stage in the uniting topic is the search task?		
Start	17	Where is South America in the world? (Y5)
Mid	18	Find in-depth information about a particular animal. (Foundation)
Final	4	Picture to decorate biography. (Y6)
Any	26	Something they ask you at the end of the day. (Y5)
Other than people what resources are used?		
A general resource	89	Weather in different countries. (Y3)
A specific resource	16	Browse Simple City to find more information for class topic. (Foundation)
What is the output?		
Articulation	15	What can you find out about the Mayan civilization. (Y6)
Construction	9	Research the habitat of a creature. (Y4)
Formal writing	25	Facts about Africa. (Y1)
Illustration	4	An image of a real animal. (Foundation)
Notes	6	Research a Rainforest animal. (Y4)
Spreadsheet	3	Cost of attractions in Sheffield. (Y6)
Vocalisation	2	“Greeting” in language “x”. (Foundation)
What is the search goal?		
General topical	44	Research a country in South America. (Y4)
Specific item	59	How to pronounce words in French. (Y3)
Unclassified	2	Shall we quickly Google that. (Y5)

Table 9: Characteristics of search tasks identified in stages 2 and 3

Stage	Objectives	Data source & collection	Data analysis
RQ1: What are the characteristics of primary school search tasks?			
1	To develop a provisional representation scheme based on what is already known about children's search tasks	Review of prior multi-dimensional representation schemes and children's information-seeking literature	Li & Belkin's (2008) search task questions used as analytic framework
2	To further develop the representation scheme based upon what is happening in the primary school IUE	A priori maximal variation sampling (1 school, 10 teachers) Semi-structured interviews	Stage 1 representation scheme used as analytic framework
3	To verify the representation scheme	Secondary data (2 schools, 3 class lessons) Classroom observations	Stage 2 representation scheme used as analytic framework
RQ2: Can search tasks with the same information use be distinguished by their characteristics?			
4	To identify search task characteristics for different information uses	Search tasks identified in stages 2 and 3	Search tasks grouped by information use, and characteristics examined

Table 1: Overview of research design

Interview guide	Li & Belkin's (2008) questions
Is this search assigned, mediated or children's free choice?	"Where is this task from?"
How are children arranged when using computers (e.g. in pairs, in groups, individually)?	"Who carries it out?"
How much time is given to conduct the search (e.g. within a single lesson or over multiple lessons)?	"How long does this task last?"
What is the purpose of the search? Why are children searching for this?	"What is it about (topic or content)?"
How does the search fit into learning objectives?	
How much is known prior to the search by the teacher or children?	"How should this task be completed?"
What do children do with the information they find?	"What is (are) its product(s)?"

Table 2: Interview guide / Li & Belkin's (2008) questions

Li & Belkin's (2008) questions	Stage 1		Stage 2	
	Question	**Answers**	**Question**	**Answers**
"Where is this task from?"	What is the work task that motivates the search task?	May be able to categorise units of work	Question removed	
	What is the nature of the motivating work task?	Routine, Typical, Unusual (Xie, 2009).	As stage 1	As stage 1
	From whom does the search task originate?	Internally-generated, Externally-assigned, Generated in collaboration (Li and Belkin, 2008).	As stage 1	As stage 1 / Teacher, Child, Teacher with class
	If a search task originates from a teacher, how flexible is it?	Highly flexible, Inflexible (Xie, 2009) / Specified topic with own focus, Specified topic with specified focus, Own topic in category with own focus, Own topic in category with specified focus, Own topic in curriculum area with specified focus, Own topic with own focus (Shenton and Dixon, 2004)	As stage 1	As stage 1 / Own topic and no framework, Own topic and framework, Own area of interest and no framework, Own area of interest and framework, Topic specified, any true, Topic specified and framework, Choice of specific question, Semi-specific information, Specific Information
"Who carries it out?"	As Li & Belkin (2008)	Individuals, Pairs, Groups (Crow, 2011)	As Li & Belkin (2008)	Individual, Individual in Group, Group (Li & Belkin, 2008) / Teacher, Child,
			Does the search task need to be completed?	Compulsory, Optional, Elective,
"How long does this task last?"	As Li & Belkin (2008)	Short term, Long term (Li and Belkin, 2008)	Does the search task occur as part of a planned search activity??	Planned, Unplanned
			What is the location of the search activity	Class, Outside of class
"What is it about (topic or content)?"	As Li & Belkin (2008)	Potentially unlimited	What is the curricular area?	Curricular subject, Event
			How is information used?	Directly to increase knowledge of a curricular subject, Indirectly to support learning of a curricular subject
"How should this task be completed?"	What is information used for?	To orient, To extend, To make sense, To illustrate, To decorate, To verify, To navigate, To define, To get instruction, To entertain, As precise data, No clear use (Authors; 2019b)	As stage 1	As stage 1
	At what stage in the work task is the search task?	Beginning, Middle, Final (Li and Belkin, 2008)	At what stage in the uniting task is the search task?	Beginning, Middle, Final, Any

	What resources are used?	Books, Information from a computer, Internet, Library, Newspapers & magazines, TV & radio, Friends, Relatives, Teachers (Madden, Ford and Miller, 2007).	As stage 1	A general resource (s), A specific resource
"What is (are) its products?"	What is the output?	No pre-existing categorisation to base answers on.	As stage 1	Articulate, Construction, Formal writing, Illustration, Notes, Spreadsheet, Vocalise
	What is the outcome?	No pre-existing categorisation to base answers on and may be difficult to determine.	Question removed	
	What is the search goal?	General topical, Specific item (Toms, 2011).	As stage 1	As stage 1

Table 3: Developing the provisional scheme

	Characteristics verified in stage 3
What is the nature of the motivating task?	Typical
From whom does the search task originate?	Teacher with class, Teacher,
If a search task originates from a teacher, how flexible is it?	Choice of specific question, Specific question, Own area of interest and no framework
Who does the search task?	Children in a group, Individual child in a group
Does the search task need to be completed?	Compulsory, Elective
Does the search task occur as part of a planned search activity?	Planned, Unplanned
What is the location of the search activity?	Class
What is the curricular area?	Subject (Science), Event
How is information used?	Indirectly to support learning of a curricular subject
What is information used for?	[1]To orient, To extend, To navigate, To verify
What stage in the work task is the search task?	Middle
What resources are used?	A general resource
What are the outputs?	Notes
What is the search goal?	Specific item, General topical

[1]To entertain verified as an information use for children's non-school work

Table 4: Validation of stage 2 scheme

1. What is the nature of the motivating work task?			
Routine		"Regular tasks that participants have to perform repeatedly" (Xie, 2009)	
Typical		"Tasks that participants are used to performing, but they have not preformed the exact same task before" (Xie, 2009)	
Unusual		"Tasks that participants have not encountered before" (Xie, 2009)	
2. From whom does the search task originate? [1]			
Internal generated	Child	"A task motivated by a task doer" (Li and Belkin, 2008)	The task can be identified as coming from one child
External assigned	Teacher	"A task assigned by task setters based on their individual purpose" (Li and Belkin, 2008)	The task is generated by the teacher
Collaboration	Teacher with class	"A task motivated through discussion of a group of people" (Li and Belkin, 2008)	The task is generated through discussion, and cannot be identified as stemming from any particular individual
3. If the search task is externally assigned, how flexible is the task? [1]			
Very flexible	Own topic and no framework (general topical goal)	"Tasks that can be changed, yet participants are still able to fulfil their work tasks" (Xie, 2009, p.351)	Children can choose their own topic and there are no particular information requirements
Flexible	Own topic and framework (general topical goal)	Tasks "can be modified in the process of achieving work tasks" (Xie, 2009, p.351)	Children can choose their own topic but particular information is required or criteria are given
	Own area of interest and no framework (general topical goal)		The broad topic is specified. Children can choose their own area of interest and there are no particular information requirements
	Own area of interest and framework (general topical goal)		The broad topic is specified. Children can choose their own area of interest but particular information is required or criteria are given
	Topic specified, any true (general topical goal)		Topic is more narrowly specified but children can find any true information for that topic
	Choice of specific question (specific item goal)		A choice of questions is given
	Semi-specific information (specific item goal)		The information requirement is specific but there is some flexibility in how to answer
Inflexible	Topic specified and framework (general topical goal)	"Tasks that cannot be changed or modified" (Xie, 2009, p.351)	Topic is highly defined and there is little or no room for individualisation
	Specific information (specific item goal)		The information requirement is specific and there is no flexibility in interpretation
4. Who does the search task?[1]			
Individual	Child	"A task conducted by one task doer" (Li and Belkin, 2008)	The child does the search task on their own
	Teacher		The teacher does the search task
Individual in a group	Individual child in group	"A task assigned and completed by different group members separately, though they are in a group" (Li and Belkin, 2008)	The child nominally does the search task on their own but is supported by other children and /or the teacher
Group	Children in groups	"A task conducted by a group of people (at least two people)" (Li and Belkin, 2008)	Children do search tasks in groups. This may be supported by the teacher.
5. Does the search task need to be completed?			
Compulsory		The task must be completed	
Optional		The task is assigned but need not be completed	
Elective		The task doer may decide whether to complete the task	
6. What are the outputs?			

Articulate	Explain and share information with others
Construction	Where something is made e.g. a cake
Formal writing	A final piece of written work
Illustration	A drawing
Notes	Taking notes
Spreadsheet	Populate a spreadsheet
Vocalise	Saying a word out loud to practice pronunciation
7. What is the search goal?	
General topical	The goal is to find information on that topic but no particular information is looked for (Author, 2011)
Specific item	The goal is to find particular information (Author, 2011)
***8. What stage in work task is the search task?**	
Beginning	"A task which just launched" (Li and Belkin, 2008)
Middle	"A task that has been running for a while and is in the middle way" (Li and Belkin, 2008)
Final	"A task that is almost done or has been completed" (Li and Belkin, 2008)
Any	The search task is not specific to a stage and could occur at any time
****9. What resources are used?**	
A general resource (s)	A general resource is used such as a library or the Internet
A specific resource	A specific resource is used such as a particular book, app, website or search service
10. How is information used?	
To orient	"To orient to a topic by seeking a broad and general understanding" (Authors, 2019b)
To extend	"To find out about a particular aspect of a topic" (Authors, 2019b)
To make sense	"To bridge a gap in understanding" (Authors, 2019b)
To illustrate	"To explain or represent an object or concept" (Authors, 2019b)
To decorate	"To visually enhance" (Authors, 2019b)
To verify	"To confirm information" (Authors, 2019b)
To navigate	"To re-find information or to find information as directed by someone else" (Authors, 2019b)
To define	"To find out the meaning or spelling of words, or synonym or translations" (Authors, 2019b)
To get instruction	"To find out how to make and do things" (Authors, 2019b)
To entertain	"To amuse" (Authors, 2019b)
As precise data	"To use data (such as price or location data) as specific unambiguous units of information" (Authors, 2019b)
No clear use	"Information searched for is not used" (Authors, 2019b)

[1] including specific application in primary schools

* For primary school search tasks, as topics are used to unite different work tasks we suggest that it is the stage of the uniting topic rather than work task that is most important.

** In primary schools, people are also invariably used as an information resource.

Table 5: Characteristics likely to be generic to all IUE

11. What is the curricular area?	
Curricular subject	List taken from national curriculum documentation (Department for Education, 2013)
Event	Where the search task is for an event and is not related to a particular curricular subject (e.g. assembly)
Non-school work	Where the information is not used for school work
12. How is information used?	
Directly to increase knowledge of a curricular subject	Where information is directly related to the curricular subject
Indirectly to support learning of a curricular subject	Where information is not directly related to the curricular subject but it is used as content with which to gain knowledge of a curricular subject
13. Does the search task occur as part of a planned activity?	
Planned	The teacher has planned for a search activity
Unplanned	The teacher has not planned for a search activity
14. What is the location of the search activity?	
Class	The search activity occurs in a school lesson
Outside of class	The search activity is not in a school lesson

Table 6: Characteristics likely to be specific to the primary school IUE

Use (10.)	Generic Characteristics									Specific Characteristics			
	1	2	3	4	5	6	7	8	9.	11	12	13	14
To orient (19)	Typical (19)	Teacher (15)	Own area & no framework (9)	Child (19)	Compulsory (16)		General (16)	Beginning (9)	General (19)			Planned (18)	
To extend (21)	Typical (19)	Teacher (17)		Child (16)	Compulsory (15)		General (19)		General (19)			Planned (20)	Class (16)
To make sense (11)	Typical (11)	Child (8)			Optional (5)		Specific (9)	Any (8)	General (9)			Unplanned (11)	
To illustrate (16)	Typical (16)	Teacher (15)					Specific (9)		General (14)			Planned (14)	
To decorate (3)	Typical (3)	Teacher (3)		Child (3)	Elective (3)		Specific (3)	Final (2)	General (3)		Indirectly (3)	Planned (3)	
To verify (2)							Specific (2)						
To navigate (5)	Typical (5)						Specific (5)						
To define (12)	Typical (11)	Child (10)		Child (9)	Elective (9)		Specific (12)	Any (11)	General (11)		Directly (10)	Unplanned (10)	Class (12)
To get instruction (2)							Specific (2)						
To entertain (0)													
As precise data (10)	Typical (8)	Teacher (6)		Child (6)			Specific (10)					Planned (10)	Class (10)
No clear use (2)	Typical (2)	Teacher (2)		Child (2)	Compulsory (2)		Specific (2)				Directly (2)	Planned (2)	Class (2)

Table 7: Typical search task characteristics for different information uses (from stage 2)

This study	Kim & Soergel (2006)	Li & Belkin (2008)	Xie (2009)
Generic characteristics			
1. Nature of work task	Routineness	Time - frequency	Nature of work task
2. Search task originator	Origin	Source of task	Origination
3. Search task doer	Task performer	Task doer	
4. Search task flexibility	Locus of decision making		Flexibility
5. Search task necessity			
6. Task outputs	Product	Product	
7. Search goal	Task structure	Goal	Search task type
8. Stage in work task	Task stage	Time - stage	Stage of task
9. Resources			
10. Information use			
Specific characteristics			
11. Curricular area			
12. How information is used			
13. Planned activity			
14. Location			

Table 8: IUE characteristics compared to multi-dimensional schemes