Making sense of multitasking: Key behaviours

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Abstract

Traditionally viewed as a positive characteristic, there is mounting evidence that multitasking using digital devices can have a range of negative impacts on task performance and learning. While the cognitive processes that cause these impacts are starting to be understood and the evidence that they occur in real learning contexts is mounting, the mechanics and extent of students’ task switching and multitasking during learning activities is neither well documented or understood. This study seeks to redress this gap by defining and describing key task switching and multitasking behaviours adopted by students. It employs computer-based task switching and self-directed learning as the technology and learning frameworks within which these behaviours are explored.

A custom monitoring system was used to capture and analyse 3372 computer session logs of students undertaking self-directed study within an open-access computer laboratory. Each session was broken down into a sequence of tasks within a series of time segments. Segments and sessions were then analysed and classified as conforming to one of three core behaviours – little or no task switching (focused), task switching without multitasking (sequential) and multitasking. Multitasking was much more common than focused or sequential behaviours. Multitasking was present in more than 70%, was most frequent in over 50% and occurred exclusively in around 35% of all sessions. By comparison, less than 10% of sessions were exclusively focused and only 7% were exclusively sequential. Once initiated, focused and multitasking behaviours appear to be quite stable. Students were much more likely to continue with them than to switch to an alternate behaviour. Sequential behaviour is far less stable and appears to represent a transitional state between multitasking and focused behaviours.

The importance of personal, social and learning contexts in setting and influencing multitasking behaviours are discussed, as are some of the potential effects of these behaviours on learning practises and outcomes.

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1. Introduction

Much has been written and spoken about today’s students’ appropriation of and preference for digital media and content. Tapscott (1998) and Prensky (2001) shaped subsequent discussion by suggesting that digital media and technologies were sufficiently influential in adolescents and young adults lives to accord them special generational status – the ‘net generation’ by Tapscott and ‘digital natives’ by Prensky. Embraced by key advocates including Oblinger (see Oblinger, 2003, 2004; Oblinger & Oblinger, 2005) and supported by evidence of widespread and rapidly increasing technology adoption from respected research organisations including PEW Research (PEW Internet & American Life Project, 2012) and EDUCAUSE (2012), the idea of a ‘net generation’ has taken root in both the educational and wider community. While some of the ‘axioms’ often associated this supposed generation of users continue to be questioned and unpacked – for example the notion that students are highly and uniformly technically skilled and prolific (Bennett, Maton, & Kervin, 2008; Jones, Ramanau, Cross, & Healing, 2010; Kennedy, Judd, Churchward, Gray, & Krause, 2008) – there seems little doubt that for a majority of students digital media and technologies play a key role in their personal and learning lives.

One of the key capabilities most often attributed to ‘net geners’, is an increased preference for and capacity to multitask (Anderson & Rainie, 2012; Oblinger, 2004; Wallis, 2006). Where this involves the use of one or more digital devices, it is typically referred to as media multitasking (Foehr, 2006; Roberts, Foehr, & Rideout, 2005). Data from a number of cross-sectional studies suggests that young
people regularly engage in media multitasking (Carrier, Cheever, Rosen, Benitez, & Chang, 2009; Foehr, 2006; Jeong & Fishbein, 2007; Smith & Boyles, 2012), and while there is little evidence to suggest they do this more effectively than older generations they do appear to do it more frequently (Carrier et al., 2009; Smith & Boyles, 2012). Of course, not all media multitasking is about socialising and entertainment – and for school and university aged students it can often involve learning activities (Foehr, 2006; Jeong & Fishbein, 2007). And, it is this interplay – between multitasking and learning – that is raising particular concerns (Anderson & Rainie, 2012; Junco & Cotton, 2012; Lee, Lin, & Robertson, 2011; Wood et al., 2012).

An ability to multitask efficiently has traditionally been viewed as a positive characteristic. It allows us to divide and apply our attention between two or more concurrent tasks. In everyday situations this can enhance the efficiency and effectiveness of how we work and manage our daily lives, particularly when it comes to the numerous simple and repetitive tasks to which we all have to attend. However, it is also well known that division of attention, and distractions in particular, can significantly impact on our performance of key tasks – the detrimental effects of mobile phone use while driving being a classic example (Lamble, Kauranen, Laasko, & Summalu, 1999; Strayer, Drews, & Johnston, 2003; Strayer & Johnston, 2001). In addition, cognitive studies indicate that some of the supposed efficiencies that multitasking confer may have been overstated, with participants in a number of studies taking longer to complete tasks performed concurrently than when performed sequentially (e.g. Pashler, 2000; Rubenstein, Meyer, & Evans, 2001). Accuracy and overall performance can also suffer (Adler & Benbaum-Fich, 2012; Ophir, Nass, & Wagner, 2009). Multitasking appears to inhibit the transfer of information into both short and long term memory (Edwards & Gronlund, 1998), and fMRI studies indicate that multitasking shifts activity from the hippocampus to the striatum (Foerde, Knowlton, & Poldrack, 2006). While the hippocampus is associated with explicit or declarative memory, the striatum is associated with procedural memory. A shift to the latter is clearly not conducive to deeper learning.

Cognitive studies of multitasking typically involve simple, discrete, well-defined tasks and are usually carried out in tightly controlled experimental situations. Student learning, on the other hand, takes place in a diversity of settings and often involves complex, ill-defined tasks. Assessing and understanding the impact of multitasking across such a wide range of contexts is by no means simple. Recent studies on the effects of multitasking in (relatively) authentic learning settings have tended to focus on the use of phones or laptops in the classroom (Fulton, Schweitzer, Scharff, & Boleng, 2011) and during lectures (Aguilar-Roca, Williams, & O’Dowd, 2012; Kraushaar & Novak, 2010; Wood et al., 2012). Almost without exception, these studies have reported negative impacts of multitasking on learning outcomes. A few studies have also looked at the role of multitasking during independent or self-directed study (Benbaum-Fich, Adler, & Mavlanova, 2011; Judd & Kennedy, 2011; Junco & Cotton, 2012), and again much of the evidence there is negative. Finally, a series of recent studies have highlighted the negative impacts of high levels of social media use, which is often implicated in multitasking behaviours, on academic engagement and performance (Junco, 2012a, 2012b; Junco & Cotton, 2012; Kirschnner & Karpinsky, 2010).

Many of these studies are concerned with the impacts that multitasking can have on learning. However, we still have a limited understanding of how students multitask during learning – how often they multitask and in what learning contexts and to what degree these multitasking behaviours vary within and between individuals. This study seeks to fill in some of the blanks by documenting and analysing the ways in which a body of students manage a diverse array of tasks within a learning context. The study is situated within an authentic, informal learning setting. It adopts a cross-sectional approach, but rather than relying on of self-reports of multitasking behaviour, which may not reflect actual multitasking practices (Brasel & Gips, 2011), it utilises automated task logs and custom analytics for data collection and analysis. While acknowledging the role of mobile phones and other digital devices in media multitasking, this study, as with others, deals exclusively with computer-based multitasking (e.g. Adler & Benbaum-Fich, 2012; Judd & Kennedy, 2011). Computers, in their various forms, are a core element of media multitasking and are integral to most students’ study practices. Given the ease with which computer-based tasks can be switched and focused by the user, computers represent ideal vehicles for studying multitasking behaviour, and therefore provide a useful model for describing and interpreting media multitasking behaviour more generally. Similarly, while the use of activity logs and analytics to support behavioural research has its limits, it can allow detailed and contextualised behavioural data to be unobtrusively captured from large numbers of users. Finally, our selection of an informal learning location and context – self-directed learning in an open access computer laboratory – rather than a formal lecture or classroom situation, recognises that a significant proportion of students’ learning takes place outside of classrooms and lecture theatres.

This study builds on the results of a companion study by the same author (Judd & Kennedy, 2011), and in doing so adopts a number of its key conventions and findings; one of the most important being the capacity to and importance of differentiating between simple task switching and multitasking when describing and interpreting users’ behaviour. That is, if a user switches between a series of tasks without returning to a previous task then, no matter how frequently those switches occur, only task switching and not multitasking has occurred. For multitasking to occur the user must switch to and from at least one task, within a series of tasks, on more than one occasion. Based on this simple differentiation, we propose, and seek to test, the existence of three basic task switching and multitasking behaviours. These being; (i) no (or very limited) task switching, (ii) task switching without multitasking, and (iii) ‘true’ multitasking. Our results are presented and discussed within this framework.

2. Methods

2.1. Data collection

The study was conducted in an open-access computer laboratory (50 seats) at a large Australian, metropolitan university. Detailed usage logs of students’ computer-based activities were captured during August and September of 2009. The computer laboratory was used by medical and biomedical students and while some timetabled and/or supervised activities were undertaken within the laboratory, the overwhelming majority of computer use was casual and self-directed. Personal and social use of the computers was permitted and there were very few restrictions on what sites students could and could not access. Usage logs comprised sequential records of application, document and Internet use and were captured on a per-session and per-user basis using a custom-built monitoring system. Details of the system are provided elsewhere (Judd & Kennedy, 2010, 2011).

The data collection protocols were almost identical to those outlined in Judd and Kennedy (2011) with any variations described below. Data collection for this study, including the monitoring of student’s computer use, was approved by the Human Research Ethics Committee of
the host University and notices were displayed on each workstation informing students that their computer use may be monitored for evaluation and research purposes.

2.2. Definition of session, task and sample

Sessions, tasks and samples are essentially as defined previously (Judd & Kennedy, 2011), with the exception that in the current study sessions from all users of the computer laboratory, and not just medical students as in the 2011 study, were included. Briefly, individual desktop applications and Internet domains accessed during these sessions were used to represent discrete user tasks and a change of task was deemed to have taken place whenever a user switched applications or (within the context of a web browser) Internet domains. Only sessions between 20 min (up from a minimum session length of 10 min in the 2011 study) and two hours duration were considered for further analysis.

2.3. Analysis by session

Each session was described in terms of its duration (time in minutes) and the number, duration, timing (start and end times) and destination (application or domain name) of its constituent tasks. These values formed the basis of all subsequent analysis.

2.3.1. Graphical representations of sessions

Graphical representations of all sessions were created to assist our understanding of temporal and contextual relationships between tasks within a session. Each session 'graph' consisted of a series of stacked horizontal bars plotted along a time axis. Each bar (row) represented a unique task (application or Internet domain), with repeat instances of specific tasks during a session being represented as a series of non-contiguous segments within a row (task). Fig. 1 includes three sample session graphs (actual session data), illustrating the three proposed basic types of task switching behaviour – (i) no task switching, (ii) task switching without multitasking and (iii) multitasking.

However, very few sessions were as simple as these and most contained a combination of two or all of the basic types of task switching behaviour – see for example Fig. 2 – requiring an analytical approach that allowed us to objectively quantify the relative contribution each type of behaviour as well as their temporal relationships to each other.

Fig. 1. Sample session graphs illustrating the three basic task switching behaviours (i) no task switching, (ii) task switching without multitasking and (iii) multitasking. Time scale (vertical grid) is in 5-min increments. Each row within a trace denotes a unique task. Blocks within a row denote instances of a task.

Fig. 2. Session graphs illustrating more complex task switching behaviour. Time scale (vertical grid) is in 5-min increments. Each row within a trace denotes a unique task. Blocks within a row denote instances of a task. The overlapping grey and white bars below Fig. 2d show the boundaries of that sessions overlapping 20 min time segments.
2.3.2. Segmentation of sessions

Individual sessions were therefore deconstructed into a series of overlapping segments. Each segment was 20 min in length and overlapped both previous and subsequent segments by 10 min. Where segment boundaries fell somewhere between the start and end of an active task – as was typically the case – the task was split, and apportioned between the two segments. Incomplete final segments were discarded.

Each segment was then classified as conforming to type 1 behaviour (no task switching), type 2 behaviour (task switching, no multitasking) or type 3 behaviour (multitasking) according to the following criteria:

Type 1 – No more than two tasks per segment (i.e. a minimum average task length of 10 min).
Type 2 – At least three tasks per segment but no specific task (same application or Internet domain) having three or more occurrences within the segment.
Type 3 – At least one specific task having three or more occurrences within the segment.

Each session was then coded as a sequence of segment types, for example the session represented in Fig. 2d consists of six full and one partial segment (segment boundaries are indicated by the overlapping grey and white horizontal bars below the session graph). Based on the number of tasks and repeated tasks within each of these segments they are coded as follows:

- 8 tasks, no repeated tasks = type 2
- 6 tasks, 1 repeated task = type 3
- 4 tasks, 1 repeated task = type 3
- 2 tasks, no repeated tasks = type 1
- 8 tasks, 2 repeated tasks = type 3
- 7 tasks, 2 repeated tasks = type 3

The entire session (Fig. 2d) is therefore coded as 233133.

All coded sessions were then classified into one of seven categories based on the following criteria:

- Category 1 – comprised entirely of type 1 segments
- Category 2 – comprised entirely of type 2 segments
- Category 3 – comprised entirely of type 3 segments
- Category 12 – containing both type 1 and 2 segments
- Category 13 – containing both type 1 and 3 segments
- Category 23 – containing both type 2 and 3 segments
- Category 123 – containing type 1, 2 and 3 segments

The categories containing more than one segment type (i.e. categories 12, 13, 23 and 123) were then further broken down into subcategories based on their most common segment type. So for example a session coded as 3312312 is classified as category 123-3, as it contains at least one segment of each type (two type 1, two type 2 and three type 3 segments) and type 3 segments have the highest frequency. When the maximum frequency is of segment types is shared by two or more types (e.g. 112332), no subcategory is assigned.

Finally, a third level of classification was applied to all type 3 segments based on the number of repeated tasks within the segment – a repeated task being one that has three or more occurrences within the segment. Subcategory A denotes a segment containing a single repeated task, B denotes a segment with 2 repeated tasks and C denotes a segment with 3 or more repeated tasks. Example traces for segments of each type are presented in Fig. 3.

2.3.2.1. Transitions. Transitions between segment types were analysed by iteratively recording the type of each segment and the subsequent segment of each type for each of the three ‘preceding’ segment types.

2.4. Analysis by user

Additional analyses were carried out using data from students who contributed at least five sessions during the data collection period. The purpose of these analyses was to determine whether particular users were or less more likely to adopt specific task switching behaviours during their sessions. Five sessions were randomly selected from each of 212 eligible users and then classified into one to the seven main categories described above. Each user was then scored according to the number of sessions (out of 5) that included type 1, 2 and 3 segments. For example, a user whose five sessions were classified as belonging to categories 23, 123, 3, 23 and 23 would return a score of 1:4:5 (type 1: type 2: type 3). A score of 4 or 5 for any of the three types denotes frequent behaviour of that type. Conversely, a score of 0 or 1 denotes infrequent behaviour of that type.

3. Results

3.1. Sessions

A total of 3372 valid sessions were captured from 1229 unique users, with each contributing a mean of 2.8 sessions. Just over one in six users (17.2%) contributed at least five sessions but only one in twenty (5.1%) contributed ten or more sessions.

On average, sessions were 53.8 ± 0.45 min long (errors estimates are standard errors unless otherwise indicated) and comprised 24.2 ± 0.27 tasks. The mean task length was 2.3 ± 0.02 min and 77.2% of all tasks were less than 5 min in duration. The mean length of the longest individual task was 19.4 ± 0.29 min and the most frequently accessed task was switched to 6.8 ± 0.07 times per session.
The 3372 sessions were comprised of a total of 13,439 time segments. Type 3 segments were the most common overall (49.5%) followed by Type 1 (28.9%) and Type 2 (21.6%). Category 3 sessions (i.e. sessions consisting entirely of type 3 segments) were the most common of the seven recognised categories, comprising 37.6% of all sessions. All other categories were much less common, ranging from a high of 16.2% for category 23 to a low of 5.6% for category 13 (Fig. 4). Category 23 sessions were dominated by subcategory 3 and category 12 sessions were dominated by subcategory 1. A more even distribution of subcategories was evident across category 123 and 13 sessions (Fig. 4).

Combining the results for individual behaviour types across all categories revealed that Type 3 segments were easily the most common, occurring in 72.2% of sessions. Type 2 segments occurred in 47.7% of sessions while Type 1 segments were the least common, occurring in 39.2% of sessions (Fig. 5). If we only consider the sessions in which each of the three behaviour types was most frequent the corresponding values reduce to 53% (Type 3), 21.4% (Type 1) and 15.1% (Type 2) respectively.

A total of 6646 type 3 segments were classified according to the number of repeated tasks they contained. Of these 28.8% contained a single repeated tasks (subcategory A), 39.7% contained two repeated tasks (subcategory B) and 31.5% contained three or more repeated tasks (subcategory C).

3.1.1. Transitions
The results of the segment analysis are represented as a pair of transition-state diagrams. These diagrams illustrate the probability that a segment of known type (and occurring at any position within a sequence) will be followed by segments of the same or other type (Fig. 6). These probabilities relate to the next segment in the sequence in Fig. 6a, and the next but one segment in the sequence in Fig. 6b. In combination, the two transition-state diagrams indicate that both type 1 and 3 segments are more likely to be followed by segments of the same type than of a different type. For example, the probability of a Type 1 segment being immediately followed by another Type 1 segment is 0.8, by a Type 2 segment is 0.14 and by a type 3 segment is only 0.06. Type 2 segments, on the other hand, are more likely to be followed by...
either type 1 or type 3 segments than they are to be followed by additional type 2 segments. Finally, when transitions from Type 1 and Type 3 segments to other segment types do occur, they are more likely to involve Type 2 segments than each other, that is the probabilities of transitioning from 1 → 2 or 3 → 2 are both greater than for transitions from 1 → 3 or 3 → 1.

3.2. Users

Among the 212 users who contributed at least five sessions, 62.3% were frequent Type 3 users (behaviour present in at least 4 of 5 randomly selected sessions), 21.2% were frequent Type 2 users, and 15.1% were frequent Type 1 users. In terms of infrequent behaviours (behaviour present in no more than 1 of 5 randomly selected sessions), the equivalent figures were 42.9% for Type 1, 21.2% for Type 2 and 8.5% for Type 3.

Almost half of the frequent Type 1 users were also frequent Type 2 users (46.9%) but only 15.6% were frequent Type 3 users as well. Frequent Type 2 users were only moderately likely to also be frequent Type 1 (33.3%) or Type 3 (37.8%) users. Frequent Type 3 users were often also infrequent Type 1 users (60.6%) but only occasionally frequent Type 2 (12.1%) or Type 1 users (4.1%) as well.

These results are in line with the results of the by-session analysis and confirm the dominance of Type 3 behaviour. While both sets of results point to a considerable amount of variation both between and within sessions for most users the by-user analysis suggests that many users display similar behaviours across sessions, the most common example being Type 3 behaviour in the absence of Type 1 behaviour.

4. Discussion

4.1. Prevalence of computer-based multitasking

The overall prevalence of computer-based multitasking is hard to gauge. Most recent studies indicate that media multitasking, which encompasses computer-based multitasking, is widespread, particularly among school and college or university aged students (Carrier et al., 2009; Foehr, 2006; Jeong & Fishbein, 2007; Smith & Boyles, 2012). Our results support this, but it is difficult to draw direct comparisons given the clear differences in context (single vs. multiple device/modalities) and methods (log analysis vs. self reports) between this and other studies. In this study, just over 70% of the computer sessions analysed involved some level of multitasking. We were initially surprised by how high this figure was as it more than double the value we reported in a previous study, based on almost identical data but collected in 2007 rather than 2009 (Judd & Kennedy, 2011). As it turns out, a substantial proportion of this disparity was due to minor methodological (data analysis) differences between the two studies. Reanalysing the data from the previous study but employing the current study’s methods increases the multitasking rate for the previous study from around 30% to above 50%. However, this still leaves us with around 20% more multitasking sessions (type 3 behaviour) and 20% fewer non- or limited task switching sessions (type 1 behaviour) in this study than the earlier one. The frequency of task switching without multitasking (type 2 behaviour) was similar for both studies.
We suspected that the remaining disparity was most likely due to compositional differences in the student cohorts involved in the two studies. The earlier study involved only medical students whereas both medical and biomedical students were involved in the current study – with medical students contributing around one third of total sessions that we captured and analysed. However, while additional analyses confirmed that medical students were less likely to multitask than other students, these differences were small – in the order of 5%. This suggests that the measured increase in multitasking, between 2007 and 2009, is real and is driven by other factors. Social media use might be involved, as the period between the two studies neatly coincides with a substantial increase students’ use of Facebook during self-directed learning session within the same computer laboratory (see Judd & Kennedy, 2010). While social media use is not the focus of this study, preliminary analysis indicates that sessions that include the use of Facebook are more likely to include multitasking behaviour than those that don’t. And, while this simple comparison doesn’t reveal whether Facebook use begets multitasking or vice versa, or if a relationship between the two is simply coincidental, it nevertheless adds weight to existing concerns that excessive use of social media can adversely impact on academic engagement and performance (Junco, 2012a, 2012b; Junco & Cotton, 2012; Kirschner & Karpinski, 2010).

Whatever their underlying motivations, the students in this study were much more likely to multitask during self-directed learning than not. This behaviour is clearly at odds with the findings from various studies of cognition and multitasking, which suggest that focussing on individual tasks and completing tasks before switching to new ones typically results in a more efficient use of time (Pashler, 2000; Rubenstein et al., 2001) and, critically, more effective learning (Adler & Benbaum-Fich, 2012; Lee et al., 2011). So, although as educators we would prefer to see students engaging in type 1 or 2 behaviours during self-directed study, few – at least in our particular learning setting – appeared to adopt or prefer this mode of learning. Moreover, if, as our results suggest, the prevalence of multitasking during self-directed learning is both high and on the increase, then it seems reasonable to assume that the routine adoption of multitasking behaviours by students is, at a minimum, reducing the effectiveness of their self-directed study. If this reduction is not adequately compensated for, then overall learning outcomes may also suffer.

4.1.1. Computer-based multitasking vs. media multitasking

Most of the attention around multitasking by adolescents and young adults has focused on so-called media multitasking, where the user ‘simultaneously’ engages with media delivered on two or more devices – for example, texting or browsing the web while watching TV. This was not our focus – our study only considered computer use – even though at least some of the sessions we captured will have involved concurrent use of other digital devices, such as mobile phones or media players. Detrimental effects of mobile phone use on learning within classroom situations have already been demonstrated (Rosen, Lim, Carrier, & Cheever, 2011; Wood et al., 2012), and would presumably extend to other learning contexts.

Media multitasking is likely to be most prevalent off campus, and particularly in the home, where students have ready access to a wider array of digital devices and media. However, whether this substantially increases the likelihood that media multitasking is incorporated into self-directed study behaviours (or vice versa) is unclear.

Irrespective of just how common media multitasking is, it seems hard to imagine that users would switch their attention between devices as frequently or as rapidly as students switch tasks in this study (every 2.3 min on average). However, when media multitasking incorporates watching TV, switches of attention can occur at much higher frequencies. In a recent study (Brasel & Gips, 2011), found that users (university students and staff) with simultaneous access to a computer and a TV switched their attention between the two devices more than four times per minute. We can only speculate at what effect such frequencies of attention switching would have on comprehension and retention if replicated in a learning context.

4.2. Making sense of task switching behaviours

We have intentionally made use of simple objective labels when defining our classifications of type switching behaviours and sessions (e.g. type 1, category 23). However, outside of their immediate context these have little meaning. How then do they relate to more generalised and recognisable patterns of study behaviour? As a first step we have developed a series of simple descriptors or labels and associated them with some of the key task switching behaviours and session categories. These labels, and brief descriptions of their associated behaviours, are as follows:

Focused – denotes type 1 behaviour. The focused student (or student exhibiting focused behaviour) attends to one or at most a small number of tasks over a relatively extended period of time. Focused behaviour is relatively common. Some 28.9% of session segments in this study were classified as focused and 39.2% of all sessions contained at least one focused segment. Focused segments were most common in 21.4% of sessions but only 9.5% of sessions were entirely focused.

Focused sessions are those in which the student concentrates their attention on one, or at most a few, resources (tasks) with few or no distracting tasks. Examples could include reading a chapter of online textbook or a journal article, listening carefully to a lecture recording or writing an essay. Most of us would probably view focused behaviour as the preferred model for self-directed study time.

Sequential – denotes type 2 behaviour. The student attends to several to many tasks in sequence, spending a relatively short amount of time on each one and only occasionally, if at all, returning to prior tasks. Sequential behaviour is the least common of the three core behaviours. Some 21.6% of session segments were sequential and 47.7% of sessions contained at least one sequential segment. Sequential segments were most common in 15.1% of sessions but only 7.1% of sessions were entirely sequential.

While cognitive studies tell us that dealing with tasks sequentially can maximise both the efficiency and effectiveness with which we complete tasks (e.g. Rubenstein et al., 2001), sequential sessions are not always indicative of efficient or effective task management. Sequential behaviours also include what we would typically refer to as browsing, where the student moves, sometimes very rapidly, from one resource to another. Browsing behaviour may be goal oriented, in which case it may be consistent with searching behaviour (e.g. locating references to support an argument in an essay), or lack focus and be relatively unstructured – more akin to ‘window shopping’.

Multitasking – denotes type 3 behaviour. The student attends to two to many tasks over a relatively short period of time and repeatedly returns to one or more of the tasks, even if only briefly. Just under one half (49.5%) of all session segments were devoted to multitasking and
72.2% of sessions contained at least one multitasking segment. Multitasking segments were the most common in 53% of segments and 37.6% of sessions were entirely devoted to multitasking.

Multitasking is the easiest to identify and complex of the three main behaviours, leading us to recognize two subcategories based on the number of repeated tasks within a multitasking segment. **Classic multitasking** refers to situations where the student switches back and forth between two (simple) or more (complex) core tasks. A common example of this that we observed was where students switched between the university’s learning management system and Facebook. Approximately 40% of the multitasking sessions in our sample involved two repeated tasks. However, the majority of these sessions did not fit the classic multitasking profile as they also included a mix of non-repeated tasks. The alternative to classic multitasking – **mixed multitasking** – refers to situations where the student combines one or more repeated tasks with several to many unique tasks; in effect a combination of sequential and multitasking behaviours. This is the most common form of multitasking. Examples would include sessions in which students were searching or browsing for learning resources and regularly checking Facebook, or editing a Word document and searching for references or information to support their arguments. Sessions where students are searching for resources using a ‘home’ site – such as the library website or a favoured search engine – as a base would also be classified as mixed multitasking under this definition. However, if we take into account students’ individual motivations and goals, such sessions would also appear to be very closely aligned with sequential searching behaviours.

**Hybrid** behaviour is used to refer to situations where students display a mixture of focused, sequential and multitasking behaviours (i.e. our category 12, 13, 23 and 123 sessions). Hybrid behaviour is quite common, accounting for just less than one half (45.7%) of all sessions. While one behaviour or other tended to dominate most hybrid sessions no specific behaviour was evident in just over 10% of all sessions. **Hybrid multitasking** denotes any mix of behaviours that includes type 3 behaviour (34.6% of sessions), while hybrid focused-sequential refers only to category 12 sessions (11.1% of sessions).

### 4.2.1. How stable are the three core behaviours?

The transitions-state diagrams (Fig. 6) confirm that focused and multitasking behaviours are both distinct and relatively stable. Focused behaviour is typically followed by more focused behaviour just as multitasking behaviour is typically followed by more multitasking behaviour. Moreover, focused behaviour is only occasionally immediately followed by multitasking behaviour, and vice versa. Sequential behaviour, on the other hand, is more likely to lead into focused or multitasking behaviour than it is to continue over an extended period. This suggests that sequential behaviour is not nearly as stable (or well delineated) as either focused or multitasking behaviours. Instead, it appears that sequential behaviour often serves as a transitional state between prior and subsequent behaviours (e.g. focused → sequential → focused or multitasking → sequential → focused). So, when shifting from focused to multitasking behaviour, rather than of immediately switching between the two, users will tend to move progressively through a succession of shorter unique tasks, gradually incorporating one or more common tasks as they go. Conversely, when shifting from multitasking to focused behaviour, rather than immediately switching from a series of interleaved tasks to a single main task, the repeated task or tasks are gradually phased out and the frequency of switches between tasks reduced until the user settles on a single main task. These sequences of events suggest that the switch between focused and multitasking behaviours isn’t necessarily a conscious or explicit one. While the intent to change may exist, the rate at which the change occurs is likely to be shaped and influenced by the type and context of the tasks they are currently engaged in.

Further evidence on the relative stability of the three main behaviours is provided through the results of the by-user analysis (Section 3.2). This analysis tells us that users who frequently engage in multitasking behaviour – around two thirds of users in our case – are unlikely to engage in focused behaviour and only slightly more likely to engage in sequential behaviour. For many users, therefore, multitasking appears to be the norm. A much smaller proportion of users regularly engage in focused behaviour (around 15%) but this behaviour is less consistent, and only around one third of these users are unlikely to engage in multitasking. A slightly greater proportion of users regularly engage in sequential behaviour (around 20%), and the transitional nature of this behaviour is further supported by the finding that these users are more likely to frequently than infrequently engage in either focused or multitasking behaviours as well.

### 4.3. The importance of context

The main and subsidiary behavioural types suggested and described in Section 4.2 are convenient in that they distill what is undoubtedly a complex spectrum of task switching and multitasking behaviours (as evidenced in Fig. 2) into a small number of relatively simple and common-sense categories. In itself, this is an important outcome of this study. However, on their own, these categories tell us little if anything of the context in which the behaviour was initiated or maintained. And, it seems reasonable to expect that behaviour will change, either subtly or substantially when the learning activity or setting changes. In this study, for example, we presume that a learning context is anything of the context in which the behaviour was initiated or maintained. And, it seems reasonable to expect that behaviour will change, whether this is caused by a change in the nature of the tasks undertaken by students, embodied in the types of applications used (e.g. word processor or...
multimedia program on anatomy) or the intended audience of the websites visited (e.g. learning management system or online gaming site). This information could be used to classify tasks into a series of broad contextual categories (e.g. personal–social, learning–information seeking). These categories could then be superimposed over the broad behavioural categories we have already outlined, allowing us to determine if and to what extent particular behaviours are associated with certain types of tasks.

4.4. Implications for self-directed learning

Almost all of the evidence to date indicates that multitasking is more likely to negatively than positively impact on learning. While there is some evidence that multitasking efficiency – that is, the mechanics of multitasking – can be improved through practice (Dux et al., 2009) any advantage this confers would appear to be more than offset by a reduction in the encoding of information acquired during multitasking into both shorter and longer-term memory (Edwards & Gronlund, 1998; Foerder et al., 2006). If computer-based multitasking during self-directed learning is as commonplace as our data suggests, then it follows that the effectiveness of students’ study per unit of time will suffer. More time and effort will be required to result in the same level of memory encoding, and learning, during a multitasking session than a focused or sequential one. The routine interleaving of non-learning with learning tasks during multitasking must already impact on the timing and quality of students’ self-directed study by either lengthening the time spent studying (to accommodate the additional time allocated to non-learning tasks) and/or reducing the effective time spent learning (if insufficient additional time allocations are made for non-learning tasks). The negative cognitive effects of multitasking can only exacerbate this.

Clearly we don’t have enough evidence to quantify the full impact of computer-based or media multitasking on learning (self-directed or otherwise) just yet. However, if we adopt a precautionary approach, then accepting that computers are central to study at a tertiary level, and commonplace at a secondary level, we should at least attempt to advise students on how to best manage and regulate their computer-based study activities and behaviours. We already recognise the need to develop sound information literacy skills among our students, and seek to address these either explicitly, through dedicated library programs, or implicitly by embedding them within integrated curricula (for example, within biomedical curricula – Jacobs, Rosenfeld, & Haber, 2003; Schilling, Ginn, Mickelson, & Roth, 1995; Scott, Schaad, Mandel, Brock, & Kim, 2000). Teaching students how to best utilise and incorporate digital devices into their study behaviours, and how to manage and prioritise the burgeoning number and variety of tasks they carry out on these devices (see for example, Rekart, 2011), may require similar approaches.

4.5. Future work

Further studies of multitasking based around the data collected for this study are currently underway. These include investigations of the relationships between task context and task switching behaviour (see Section 4.3) and Facebook use and multitasking prevalence (see Section 4.1). Beyond that our focus will shift towards mobile learning devices and contexts. Smartphone ownership in the 18–35 age group is well over 50% and growing rapidly and college and university students, are increasingly using smartphones and tablets to access online and learning content (Dahlstrom, de Boor, Grunwald, & Vockley 2011; Rainie, 2012; Smith, 2012), supplementing and potentially supplanting laptops and computers as their primary digital learning tool. Developing a monitoring system capable of capturing the sort of data used in this study presents a number of challenges and our initial efforts will concentrate in that area.

References


