3

Navigation in the PISA 2009 Digital Reading Assessment

Navigation is a key feature of digital reading. Tracking and analysing the sequences of pages students visit to complete a task can help to identify which navigation behaviours are associated with greater digital reading proficiency. In addition to examining this relationship, the chapter presents a series of case studies showing how students respond to certain digital reading tasks.

As discussed in Chapter 2, navigation is considered to be part of the cognitive process of digital reading. In addition to locating clickable links within texts, students are required to predict what kind of information they will encounter once these links are opened, including its likely utility or relevance to the task in which they are engaged. These cognitive processes themselves are not directly observable; however, there are traces of the results of at least some of this cognitive activity in the navigation pathways that students follow. Tracking and analysing the sequences of pages students visit provide insights into navigation behaviours that, in turn, can ultimately suggest which kinds of navigation behaviour are more or less likely to be effective in digital reading.

This chapter examines how general patterns of navigation behaviour across tasks, and navigation patterns in response to individual tasks, relate to overall proficiency in digital and print reading. It also presents a series of case studies, illustrating student behaviour in response to a number of digital reading tasks.

GENERAL PATTERNS IN THE RELATIONSHIP BETWEEN NAVIGATION AND PERFORMANCE IN DIGITAL AND PRINT READING

One of the major distinctive features of digital text or, more specifically, hypertext (see OECD, 2009b, p. 22), is that it consists of several pieces of text, or "nodes", that are interconnected via hyperlinks (see Chapter 1). The reader is required to select pieces of text and put them into an appropriate order so that both the selection and the ordering fit both the reading goal and the learner's cognitive resources, such as their prior knowledge (Salmerón, *et al.*, 2006). This process of selecting and ordering pieces of textual information in hypertext is referred to as "navigation" (see Lawless and Schrader, 2008, for an in-depth discussion of the "navigation" metaphor).

A considerable number of studies have found that navigation is closely linked to understanding digital texts. This is because in digital reading, a reader "constructs" his or her text through navigation. Thus, his or her navigational choices directly influence what kind of text is eventually processed. This affects both the text's content and structure. Navigation choices will determine which pieces of information will be accessible to the reader, and whether that information is appropriate to the task at hand. They will also determine whether the pieces of information accessed will be in a semantically coherent order, and thus require more or less cognitive effort to be understood (Kintsch, 1998).

A wide variety of methods has been used in prior research to describe students' navigation behaviour (Naumann, 2008; Richter, *et al.*, 2003; and Rouet and Passerault, 1999). Among these are graphical methods that fully describe a given reader's navigational path. To relate navigation to measures of comprehension or learning outcomes statistically, however, navigation behaviour has to be captured in some metric or scale.

In the most simple case, this metric can be qualitative (or "nominal") and classify students in terms of whether their navigational behaviour falls into one or another category. An example of such a scale is classifying students as to whether they performed a specific navigation action or not – for example, whether or not they clicked on a particular link. Another example is the distinction between different "types" of navigators, who differ in more than one aspect of their navigational behaviour. Lawless and Kulikowich (1996), for instance, looked at seven different navigational indices, such as the proportion of relevant pages accessed, the proportion of special features accessed, such as movies or sound effects, or the number of deviations from an optimal path. These seven indices served as the basis for a cluster analysis. This analysis resulted in grouping students into three clusters, identified as "knowledge seekers", "feature explorers", and "apathetic users". Within this classification, "knowledge seekers" were those who navigated in a very structured and task-oriented way, and were not easily distracted by task-irrelevant text content or devices. These users usually scored best on a reading-recall measure. "Feature explorers" tended to investigate each and every feature in the hypertext, especially its technical features. A student belonging to this class of user would probably click on a video or an animation that looked interesting or appealing, more or less regardless of its importance to completing the particular learning task. These users scored second best. "Apathetic users" were not easily distracted, but they did little navigating: their paths were usually short, and their information-seeking behaviour did not meet the requirements of the task. These users scored the worst.

A reader's navigational behaviour can also be described by one or more variables indicating the *extent* to which he or she performed pre-defined acts of navigation, leading not to a discrete classification, or a nominal scale, but to an ordinal or an interval scale. One variable of this kind that has been used widely in describing task-oriented navigation is the extent to which readers access task-relevant information within the digital text environment. A straightforward and frequently used way to measure task-oriented navigation is to count the number of task-relevant

page visits, or to take the ratio of task-relevant visits, divided by the number of page visits. This variable has proven to be highly predictive of learning outcomes in hypertext or hypermedia learning (Cress and Knabel, 2003; McDonald and Stevenson, 1998a, 1998b; Naumann, *et al.*, 2008).

In addition to accessing information, ordering information is crucial for proper comprehension of hypertext materials. Students who fail to organise the material they read in a semantically coherent order are at a disadvantage, especially if they have minimal prior knowledge and they are thus not in a position to bridge gaps in understanding by appropriate inferences (Salmerón, *et al.*, 2005). Thus, one theoretically important aspect of navigation is captured by indices that look not only at individual page visits, such as visits to task-relevant pages, but at movement between pages, that is, semantically coherent *vs.* incoherent movement between pages belonging to the same hypertext node *vs.* movement between pages belonging to different hypertext nodes.

Relevance of pages

The PISA 2009 digital reading assessment tasks were deliberately constructed so that navigation was required to obtain full credit. Thus, in some tasks, students were required to go through a number of pages to access the information they needed to complete the task, or to integrate information from at least two different pages. For example, in the unit "*IWANTTOHELP*", students engage with a blog entry written by a girl named "Maika", who discusses her intention to start a volunteer job. From the blog entry, a text-embedded link refers to a site from a non-profit organisation called "iwanttohelp", where volunteering opportunities are offered. In Question 3 of this unit, students are asked to define the purpose of the "iwanttohelp" website. To answer the question, students first have to use the link to the "iwanttohelp.org" website, and then have to determine that this website's aim is "providing people with information about ways to volunteer" (as stated in one of the multiple-choice options). In this task, in addition to the two pages that students need to visit to receive a score in this item (unless they guess), there are a number of additional pages that might reasonably be assumed to be helpful in determining the purpose of the iwanttohelp website, such as an FAQ page or an "About" page, which can be accessed using a site map. In each task there are a number of pages that will only be chosen by students as a result of poor comprehension, as those pages contain no relevant information. Thus, each unit contains three types of pages: those that must be visited to complete a given task (necessary pages), those that either are necessary or might be useful in completing the task (relevant pages), and those that are clearly irrelevant to the task (irrelevant pages). Thus, the necessary pages are a subset of the relevant pages (each necessary page is also relevant, but not the reverse).

Indicators used to describe navigation

Three indicators are used to describe students' navigation behaviour. First, as a rough index of how intensely students use the environment overall, the *number of page visits* is examined. This comprises visits to any pages, regardless of their relevance to the task, and regardless of whether each is a first visit to the page or a revisit. Students with a very low score on this variable might be called "apathetic" according to Lawless and Kulikowich (1996). Second, the *number of visits to relevant pages* is taken into account. This index describes how often students accessed a page that contains task-relevant information, has to be accessed to find task-relevant information, or can be assumed to contain task-relevant information. This index describes the overall intensity of students' task-oriented navigation behaviour.

Box VI.3.1 Example of navigation indices

The following sample pathway illustrates how the navigation indices *number of page visits, number of visits to relevant pages,* and *number of relevant pages visited* are computed:

Step No.	Page accessed	Description
1	"**Page 1**"	In this example, the pages that are considered relevant to the task are marked in **bold** (pages "1", "4" and "5"). Thus, a student displaying this path would be assigned seven as the *number of page visits*, corresponding to the total length of the path, or the number of steps taken. The *number of visits to relevant pages* would amount to four, since the student visited a page classified as relevant four times (in steps 1, 3, 5 and 6). Finally, the *number of relevant pages visited* would amount to three, since three *different* relevant pages were accessed (pages "1", "4" and "5").
2	"Page 2"	
3	"**Page 1**"	
4	"Page 3"	
5	"**Page4**"	
6	"**Page 5**"	
7	"Page 3"	

However, this index says nothing about how comprehensively a student covers the material that is potentially relevant to the task. In theory, a student could switch back and forth between two pages that are both relevant to a task, and thus obtain a large number of visits to relevant pages, despite seeing only a small part of the material, and without navigating in any straight or task-oriented way. Given this possibility, the *number of relevant pages visited* is calculated. This index describes how many of the pages judged to be relevant to a task were accessed while the student worked on that task.[1] The tracking and analysis of the sequences of pages students visit to complete a task to identify navigation behaviours associated with greater digital reading proficiency is one of the major aspects of assessing student competencies that ICT enable.

The two indices relating to visits to task-relevant pages can be expected to be positively associated with digital reading performance. In the case of the *number of relevant pages visited*, the assumption is clear: the greater the proportion of relevant pages a student visits, the more likely the student is to succeed in that task, and the better he or she is likely to perform in the assessment as a whole. This is because before understanding the content of a text that is necessary or relevant to a given task, the text itself must first be accessed. A positive association with performance can also be assumed for the *number of visits to relevant pages*, since students who include more visits to relevant pages in their navigational paths will have navigated more systematically and will have had access to more task-relevant information than students who had fewer visits to relevant pages. *Revisits* to task-relevant pages can be a sensible navigation strategy.

The relationship between *number of page visits*, that is, the mere length of a students' navigational path, and performance is unclear. While some studies find path length to be positively associated with learning outcomes (Barab, *et al.*, 1996; Brunstein and Krems, 2005; Lin, 2003), others find no such association (McEneaney, 2001; Naumann, *et al.*, 2007). The different findings might be related to the origin of the path lengths. For example, a path length might be the result of a student getting lost and attempting to find his or her way back to a better path. This path length would have a negative association with performance. The same would be true if the path length were the result of idle and distracted navigation. On the other hand, if path length is a result of comprehensive coverage

Box VI.3.2 How the findings are organised

The findings relating to navigation in the PISA digital reading assessment that use indices aggregated across tasks are organised as follows:

First, the distribution (mean, standard deviation, median, skewness) of the three indicators of navigation (number of page visits, number of visits to relevant pages, and number of relevant pages visited) is given for each country. Within countries, the mean and standard deviation of all three indicators are also plotted against each other, and against countries' mean digital reading scores. Then, correlations between the three indicators and between both digital and print reading scores are reported.[a] Correlations between print reading scores and navigation, and between digital reading scores and navigation, are also reported. Regression analyses that introduce navigation as a predictor of digital and print reading performance are then reported. These analyses show whether students with similar levels of print reading proficiency differ in their digital reading performance, depending on their navigational behaviour. Finally, regression analyses that consider non-linear trends in the prediction of performance based on navigation are discussed. A moderate, as opposed to a low, number of visits to relevant pages can be expected to benefit performance, especially if revisits are included. However, when students go beyond a moderate number of visits to relevant pages, for example by moving frequently back and forth between two (relevant) pages, it might not improve their performance. Thus, the impact of increasing numbers of visits to relevant pages on digital reading performance might be expected to be diminished. The same holds for the number of page visits. Figure VI.3.1 illustrates the non-linear relation between the number of relevant page visits and digital reading performance. A similar curve is expected for the number of page visits.

Following these analyses, case studies of navigation behaviour in six individual tasks are analysed and related to performance

a. Here, and in the rest of this chapter, Weighted Likelihood Estimates (WLEs) are used for both digital and print reading proficiency scales because indices of navigation were not included in the background model for the computation of Plausible Values (PVs), and thus cannot be used as predictors in regression models using PVs as dependent variables.

of available material, with a lot of visits, and goal-oriented revisits, to task-related materials, or the exploration of pages considered relevant, the number of page visits will have a positive association with performance.

Distribution of navigation indices at the country level

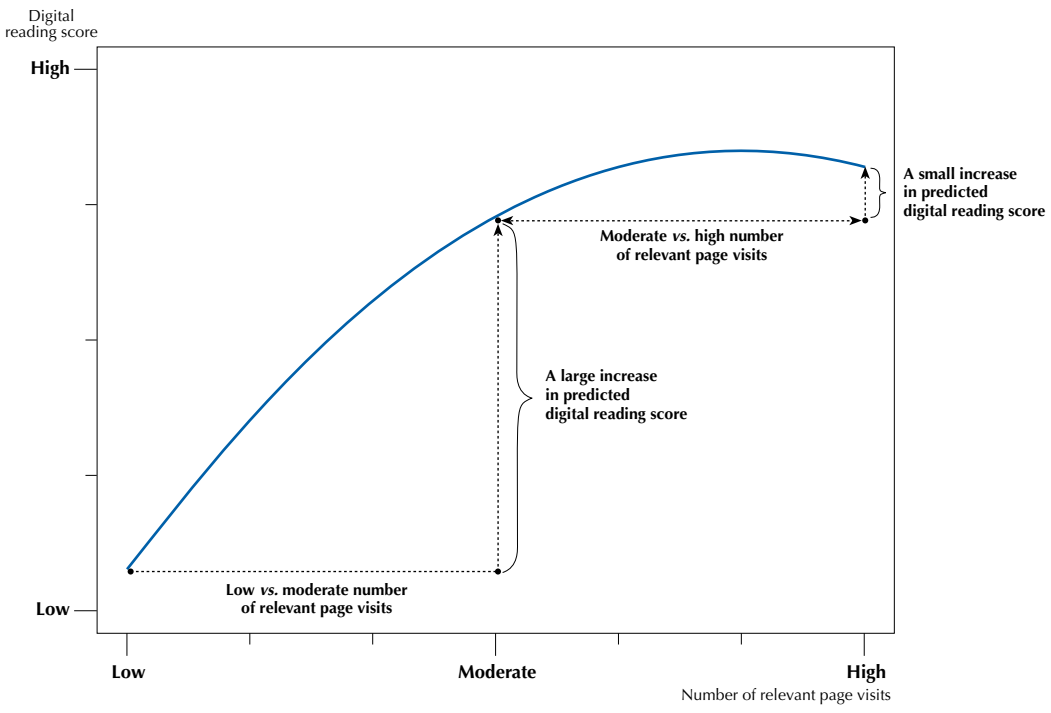
The distribution of navigation indices within countries is slightly skewed for each index, especially for the number of relevant pages visited and the number of page visits. The number of relevant pages visited is skewed to the left in every country except Colombia, where the skew is to the right (Table VI.3.1). The number of page visits is consistently skewed to the right in every country (Table VI.3.1).

This means that for the number of relevant pages visited, the median is larger than the mean because some, although comparatively few, students perform differently from the majority in that they visit relatively few relevant pages. For the number of page visits, the mean is larger than the median. Here, relatively few students access and revisit pages much more often than the majority. Overall, the skewness of the frequency distributions of navigation indicators is less pronounced than it often is in the small-scale studies reported in the literature (for example, the *number of visits to relevant pages* in Naumann, *et al.,* 2008).[2] Figure VI.3.2 illustrates the distribution of navigational indices aggregated across OECD countries; the overall shapes of the distributions within countries are the same as the shape of the distributions that result when the data are aggregated across OECD countries.

Across countries and economies, there is wide variation in the distribution of the navigation indices considered (Table VI.3.1). For instance, with respect to the mean *number of relevant pages visited,* students in Korea saw an average of 53 pages, while in Colombia they saw only 31 pages. The same holds for the mean *number of visits to relevant pages*, which varies between 44 (Colombia) and 74 (Korea), and the mean *number of page visits*, which varies between 58 (Colombia) and 100 (Macao-China). These differences, especially those in the *number of relevant pages visited,* match closely country differences in digital reading performance (Figure VI.3.3).

■ Figure VI.3.1 ■

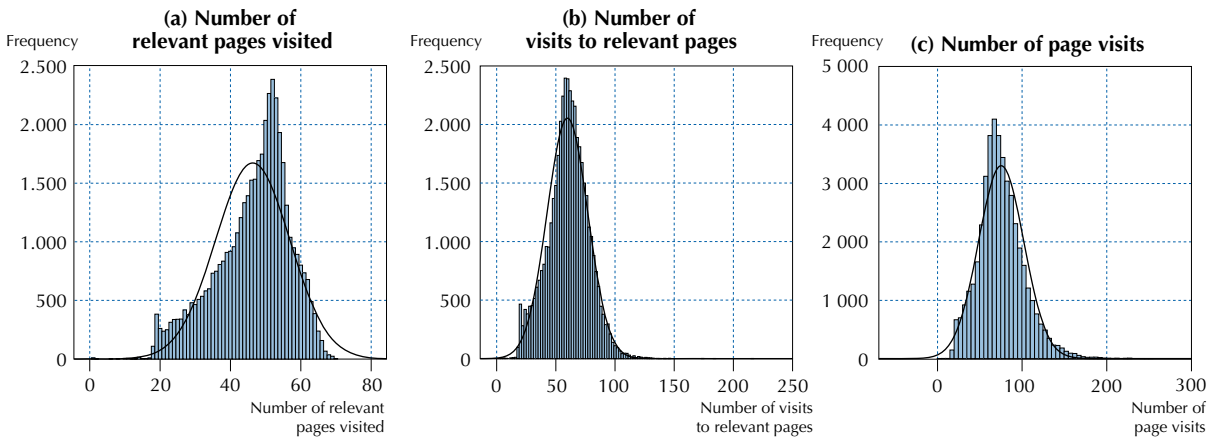
Illustration of the relationship between number of relevant pages visited and digital reading performance



StatLink http://dx.doi.org/10.1787/888932435397

■ Figure VI.3.2 ■

Distribution of the number of pages and visits, aggregated across OECD countries

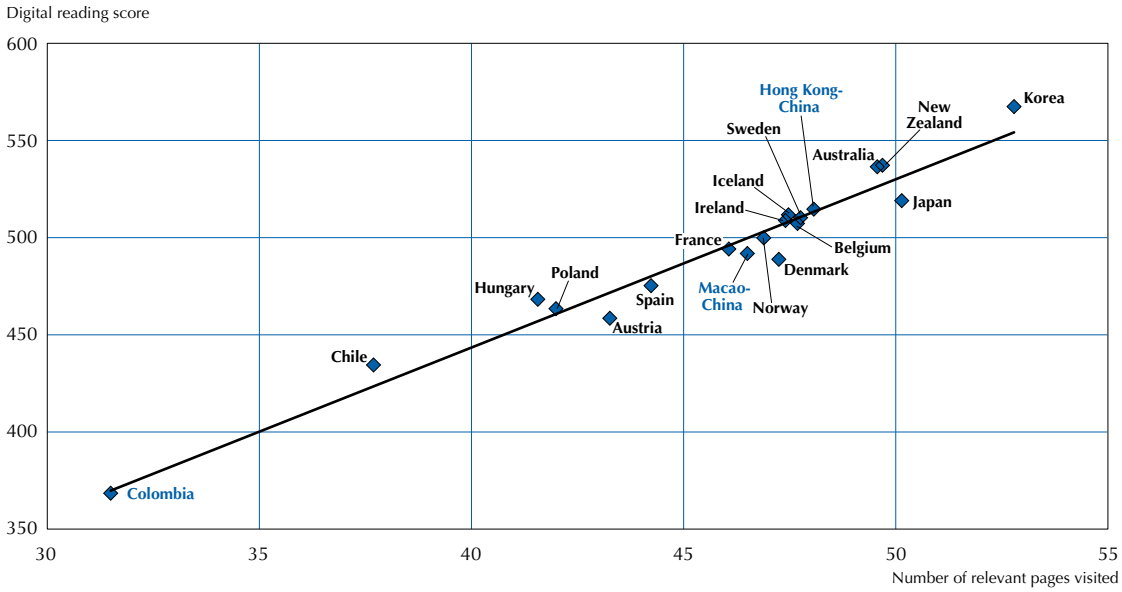


Source: OECD, *PISA 2009 Database*.
StatLink http://dx.doi.org/10.1787/888932435397

At the country/economy level, both the Pearson and rank-order correlations between the mean number of relevant pages visited and the mean digital reading score amount to 0.98.

■ Figure VI.3.3 ■

Relationship between the number of relevant pages visited and digital reading performance

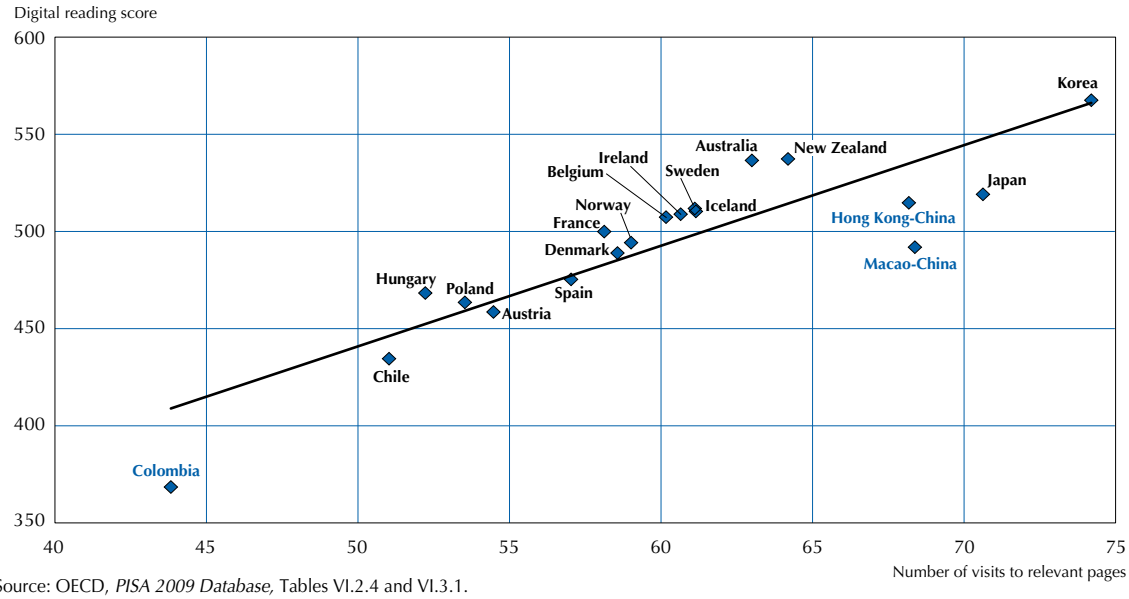


Source: OECD, *PISA 2009 Database*, Tables VI.2.4 and VI.3.1.
StatLink http://dx.doi.org/10.1787/888932435397

The relation is somewhat less clear concerning the *number of visits to relevant pages* and the *number of page visits*. The reason is that students in the participating Asian countries and economies were more likely to revisit relevant pages and to explore pages beyond those considered relevant (Figures VI.3.4 and VI.3.5).

■ Figure VI.3.4 ■

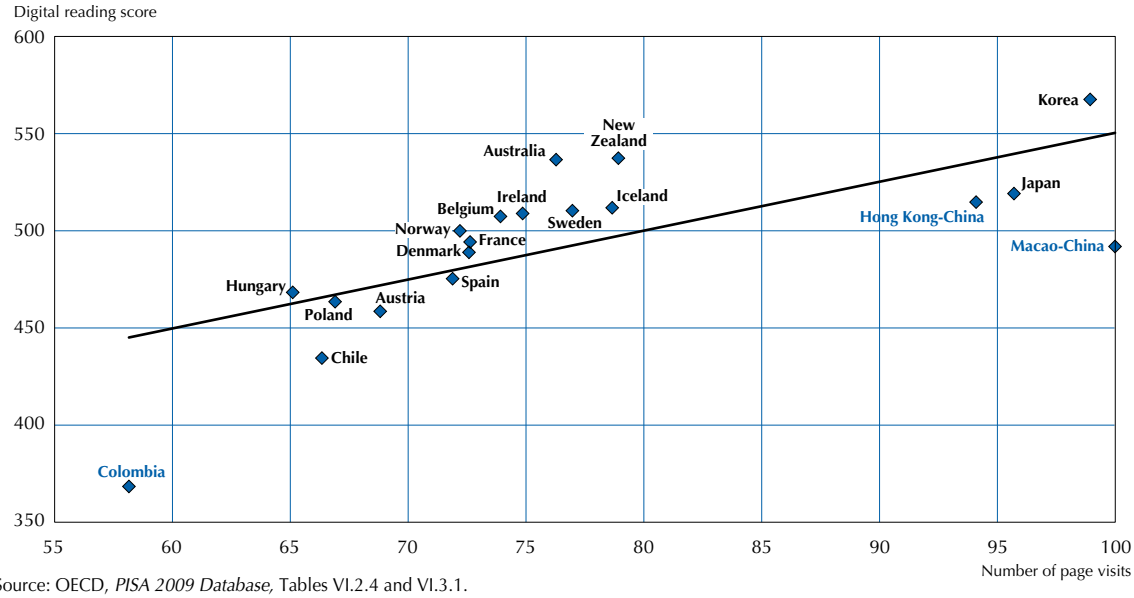
Relationship between the number of visits to relevant pages and digital reading performance



Source: OECD, *PISA 2009 Database,* Tables VI.2.4 and VI.3.1.
StatLink http://dx.doi.org/10.1787/888932435397

■ Figure VI.3.5 ■

Relationship between the number of page visits and digital reading performance



Source: OECD, *PISA 2009 Database,* Tables VI.2.4 and VI.3.1.
StatLink http://dx.doi.org/10.1787/888932435397

While the difference between the mean *number of page visits* and the mean *number of relevant pages visited* is 29 for the OECD average, it is 46 for Japan, Korea and the partner economy Hong Kong-China, and as high as 53 for the partner economy Macao-China.

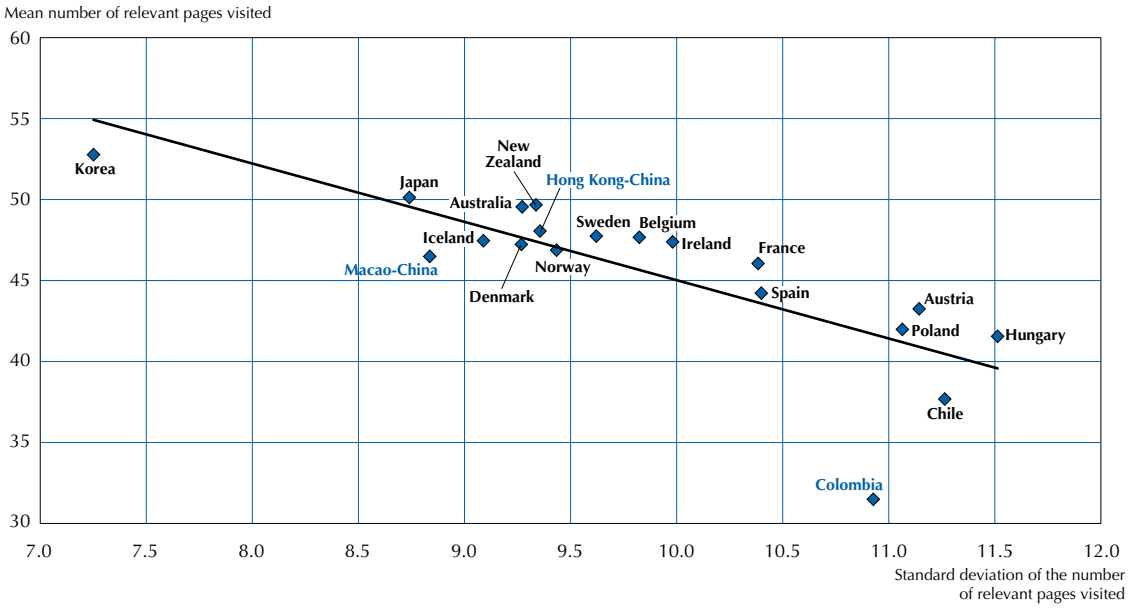
Not only across countries and economies, but also within countries there is considerable variation in each navigational index, as indicated by within-country standard deviations (Table VI.3.1). Standard deviations in the *number of relevant pages visited* range from 7.3 (Korea) to 11.5 (Hungary). Standard deviations in the *number of visits to relevant pages* range between 14.3 (New Zealand) and 20.0 (Colombia). Standard deviations in the *number of page visits* range from 22.4 (Denmark) to 34.1 (Macao-China).

All tasks were constructed so that students had to navigate (see Chapter 1). However, in a number of tasks, students were given guidance on how to navigate most efficiently, such as which link to click on first on the start page, and instructions on how to minimise the risk of getting "lost". It is thus a significant finding that students differ to a large degree in the *number of relevant pages visited,* in the *number of visits to relevant pages* and in the *number of page visits*. If, in tasks where guidance was provided, a large majority of students had followed the instructions on how to navigate, and if they had found for themselves the shortest route, there would have been much less variation in all three indicators.

The amount of within-country variation that occurs in the *number of relevant pages visited* has a negative relation both with the *number of relevant pages visited* and with digital reading scores at the country/economy level (Figures VI.3.6 and VI.3.7). At that level, the Pearson correlation between the within-country standard deviation in relevant pages visited and the mean *number of relevant pages visited* is -0.79 while the rank order correlation is -0.81. The Pearson correlation between the within-country standard deviation in *relevant pages visited* and the mean digital reading score is -0.79, and the rank order correlation is -0.77. For instance, students in Korea, who scored highest in digital reading and also had the highest *number of relevant pages visited,* at the same time had the lowest standard deviation in the *number of relevant pages visited* (7.3). In contrast, students in the partner country Colombia, who scored lowest in digital reading, displayed large variations in the number of relevant pages visited (standard deviation 10.9). Likewise, students in Chile, who had the second lowest performance in digital reading and visited the second lowest mean *number of relevant pages,* had the second highest standard deviation in the *number of relevant pages visited* (11.3).

■ Figure VI.3.6 ■

Relationship between standard deviation and mean of the number of relevant pages visited

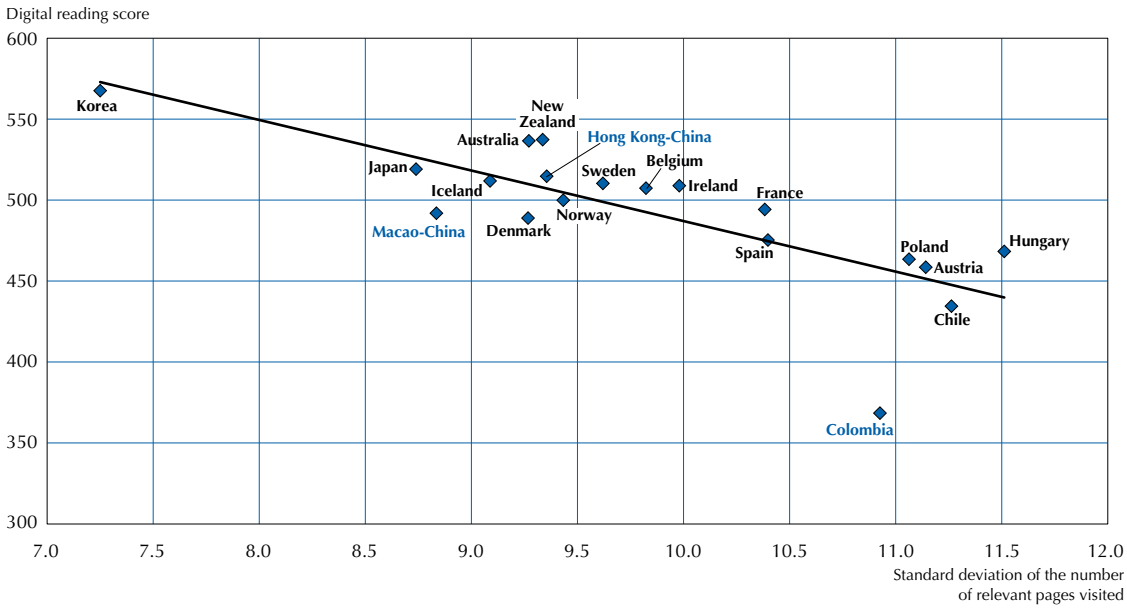


Source: OECD, *PISA 2009 Database,* Table VI.3.1.
StatLink http://dx.doi.org/10.1787/888932435397

In part, the negative correlation between standard deviation and mean across countries is due to the fact that in some countries there was a tendency for most students to visit all relevant pages, in which case the standard deviation was close to zero. It is not likely, however, that the negative relation between standard deviation and mean in the *number of relevant pages visited* is entirely due to a ceiling effect. Depending on the test version administered, the *number of relevant pages* available was 63, 73 or 76; but even in countries and economies where students visited high numbers of relevant pages (*e.g.* 53 in Korea or 48 in Sweden and Hong Kong-China), the mean *number of relevant pages visited* was well below the maximum number of relevant pages.

■ Figure VI.3.7 ■

Relationship between standard deviation of the number of relevant pages visited and digital reading performance



Source: OECD, *PISA 2009 Database*, Tables VI.2.4 and VI.3.1.
StatLink http://dx.doi.org/10.1787/888932435397

Thus, in countries and economies where students succeeded, on average, in accessing a large proportion of the material relevant to the task, for example, Korea, Japan, New Zealand, Australia and Iceland, only a few students did *not* succeed in accessing a large amount of relevant material, resulting in comparatively little variation in the *number of relevant pages visited* (Figures VI.3.6 and VI.3.7). At the same time, these are the countries where students performed better in digital reading.

Relationships among navigation, print and digital reading

As outlined above, navigation can be assumed to be closely associated with proficiency in digital reading. However, correlations between navigation and print reading can also be assumed, for a number of reasons. First, in assessments such as the PISA 2009 digital reading assessment, the task is presented in written form. Second, most navigational devices, such as text-embedded links, menu items, or items in a drop-down menu, have textual labels that have to be deciphered. Thus, lower-level reading processes, such as word identification or syntactic parsing, are one prerequisite for navigation. In addition, these processes should be routine in order to leave available cognitive resources for making navigational choices (Naumann, *et al.*, 2008). Third, to make appropriate predictions, for example, about where a text-embedded link will lead, and thus whether it makes sense to use it, its textual context has to be considered and understood. Thus, text-level reading skills are required in addition to routine lower-level processes for efficient navigation.

Despite these considerations, navigation is a process that is specific to digital reading, even if it might be affected by proficiency in print reading. Thus, while there may be associations between print reading and navigation, they are likely to be stronger between digital reading and navigation. This is because navigation is considered to be a specific and integral part of digital reading, as outlined in the *PISA 2009 Assessment Framework* (OECD, 2009).

Correlations between navigation and performance

Navigation and digital reading performance

Bivariate correlations between the three indicators of navigation and digital reading performance are all positive, and strong for the number of *relevant pages visited* (Table VI.3.2). As expected, correlations are highest for the *number of relevant pages visited,* ranging from 0.68 (Korea) to 0.86 (Hungary), followed by the *number of visits to*

relevant pages, that range from 0.39 (Korea) to 0.75 (Hungary). Correlations between the *number of page visits*, not taking task relevance into account, are still positive, but comparatively small, ranging from 0.15 (Macao-China) to 0.59 (Hungary).

On average across OECD countries that participated in the digital reading assessment, correlations between navigation and digital reading performance are 0.81 (*number of relevant pages visited*), 0.62 (*number of visits to relevant pages*), and 0.42 (*number of page visits*).

Navigation and print reading performance

There are significant positive associations between print reading performance and with navigation as well. These are, however, consistently weaker for print reading than for digital reading (Tables VI.3.2 and VI.3.3). Correlations of the *number of relevant pages visited* with print reading scores range from 0.43 (Macao-China) to 0.72 (Hungary); correlations of the *number of visits to relevant pages* with print reading scores range from 0.24 (Macao-China) to 0.63 (Hungary); and correlations of the *number of page visits* with print reading scores range from 0.06 (Macao-China) to 0.51 (Hungary).

On average across OECD countries that participated in the digital reading assessment, the correlations of navigation indices with print reading scores are 0.62 (*number of relevant pages visited*), 0.48 (*number of visits to relevant pages*) and 0.33 (*number of pages visited*). Thus, consistent with the need to employ reading skills in order to accomplish navigation tasks, navigation is related not only to digital reading, but to print reading as well. At the same time, corresponding correlations between indices of navigation are stronger for digital than for print reading (Tables VI.3.2 and VI.3.3).

Regression of digital reading performance on print reading and navigation

Multiple regression analyses were conducted to test whether navigation would be predictive of digital reading performance after accounting for print reading proficiency. These analyses provide a crucial test for the claim that navigation – as captured by the indices used here – is a specific and integral part of digital reading, especially given that navigation is correlated not only with digital reading but also with print reading scores. Theoretically, one model that could account for the data presented thus far would assume that good navigation is a by-product of good print reading proficiency, which also influences digital reading proficiency (Salmerón and García, forthcoming). In this case, correlations between navigation and digital reading achievement should be close to zero when print reading proficiency is accounted for. In other words, if good navigation were a by-product of good reading proficiency, and thus correlated with digital reading scores, in a multiple regression of digital reading scores on print reading and navigation, navigation should have no increment in variance explained over and above what is already explained by print reading. Although such a model is not considered seriously in the hypertext literature, rarely has it been put to the test: in most studies investigating the impact of navigation on comprehension in electronic environments, no independent measure of print reading proficiency has been included. Thus, there is little evidence of an association between navigation and digital reading comprehension after accounting for print-reading proficiency.

Number of relevant pages visited

In a regression of digital reading scores on print reading scores and the *number of relevant pages visited*, the regression coefficient for both predictor variables is significant for each country (Table VI.3.4).

This means that students with the same level of print reading proficiency will still differ in their predicted digital reading achievement, depending on how many relevant pages they visited. On the other hand, students accessing an equal number of task-relevant pages will still differ in their predicted digital reading score depending on their print reading proficiency. The magnitude of the effects of navigation conditional on print reading, and of print reading conditional on navigation, can be examined by inspecting both the regression coefficients and the amount of unique variance explained by each predictor.

Regression coefficients for the *number of relevant pages visited* range from 5.22 in the partner country Colombia and the partner economy Macao-China, to 6.93 in France, with an average of 6.40 across all participating OECD countries. This means that for students with similar print reading proficiency, their predicted digital reading score is increased by between about five and about seven score points for each relevant page visited. Regression coefficients for print reading proficiency vary between 0.23 in Japan and 0.39 in New Zealand, with an average of 0.31 across all participating OECD countries.

Thus, for students who visit an equal number of relevant pages, their predicted digital reading score is increased by between 2 and 4 score points with each additional 10 score points gained on the print reading scale.

The increase in variance explained in digital reading (ΔR^2) that is obtained when the *number of relevant pages visited* is included in the model, in addition to print reading proficiency, ranges from 16% (Korea) to 31% (France), with an average increase of 23% across all participating OECD countries. Including print reading proficiency as a predictor of digital reading proficiency, in addition to the *number of relevant pages visited*, increases the variance explained in digital reading by between 4% (Poland and Spain) and 11% (Korea and Macao-China), with an average of 6% across all participating OECD countries. In terms of conventions for effect sizes (Cohen, 1988), the effect of navigation on digital reading performance after accounting for print reading proficiency is large, with an effect size f^2 that ranges from 0.38 in Korea to 1.32 in France, with a mean of 0.83 across all participating OECD countries.[3] Effect sizes for print reading proficiency, while accounting for the number of relevant pages visited, are also large by convention, but smaller than those obtained for navigation.

This analysis suggests that navigation ability is an additional component of reading in the digital medium, beyond the other abilities that students have, and employ, in print reading. Although there is overlap with print reading, performance is improved when students navigate effectively, that is, when they maximise *visits to relevant pages*.

Number of visits to relevant pages

In a regression of digital reading performance on print reading performance and the *number of visits to relevant pages,* regression coefficients are significant for the *number of relevant page visits* consistently across countries, ranging from 1 in Korea to 3 in Austria (Table VI.3.5), with an average of 2.4 across all participating OECD countries.

This means that for students with equal proficiency in print reading, their digital reading score increases by between 1 and 3 score points for *any* visit to a relevant page, whether this page has already been visited or not. Regression coefficients for print reading proficiency vary between 0.38 (Japan) and 0.60 (New Zealand), with an average of 0.50 across all participating OECD countries. This means that accounting for the *number of visits to relevant pages*, students' digital reading score increases by between 0.38 score points and 0.60 score points for each additional score point on the print reading scale.

The increase in variance explained in digital reading proficiency that is obtained when the *number of visits to relevant pages* is included in the model, in addition to print reading proficiency, ranges between 3% (Korea) and 14% (Austria and Hong Kong-China), with an average of 11% across all participating OECD countries. Including print reading proficiency as a predictor, in addition to *number of visits to relevant pages*, increases the variance explained by between 14% (Hungary) and 29% (Korea), with an average of 20% across all participating OECD countries. Effect sizes in these analyses range from medium to large for the *number of visits to relevant pages* and are large for print reading proficiency (Table VI.3.5). Thus, although once again both print reading proficiency and navigation can be proven to account for independent proportions of variance in digital reading performance, the pattern of results is in one way reversed in comparison to the analysis involving the *number of relevant pages visited*: taking the *number of relevant pages visited* as an indicator of navigation, and as a predictor of digital reading performance, in addition to print reading proficiency, the *number of relevant pages visited* accounts for a larger proportion of unique variance than print reading proficiency does. Taking the *number of visits to relevant pages*, rather than the number of *relevant pages visited*, as an indicator of performance reverses this pattern. Here, a larger proportion of unique variance is accounted for by print reading proficiency than by *the number of visits to relevant pages*.

Number of page visits

In a regression of digital reading performance on the *number of page visits* and print reading proficiency, all regression coefficients are positive and significant (Table VI.3.6). Regression coefficients for the *number of page visits* range from 0.26 (Korea) to 1.26 (Austria), with an average of 0.92 across all participating OECD countries (Table VI.3.6).

This means that the predicted digital reading performance for students with the same print reading proficiency is increased by between 0.26 and 1.26 score points per *additional visit to any page*, whether it is relevant to the task or not. For print reading proficiency, in this analysis, regression coefficients varying between 0.43 (Japan) and 0.70 (New Zealand) are obtained, with a mean of 0.61 across all participating OECD countries. In terms of unique variance accounted for by each of the predictors, the effect for the *number of page visits* varies between 1% additional variance

explained (Korea and the partner economy Macao-China) and 8% additional variance explained (Norway), with an average of 5% across all participating OECD countries. In contrast, the unique variance accounted for by print reading proficiency in this analysis varies between 23% (Colombia) and 49% (New Zealand), with an average across all participating OECD countries of 34%. Effect sizes for each of the predictors range from small to medium for the *number of page visits* and are large for print reading proficiency (Table VI.3.6). Thus, similar to what has already been seen for the *number of visits to relevant pages*, and in contrast to what was found for the *number of relevant pages visited*, print reading proficiency accounts for considerably larger proportions of unique variance than does the *number of page visits*.

Taken together, the results presented in this section indicate clearly that navigation has positive associations with digital reading performance even when print reading proficiency is accounted for. In the case of the *number of relevant pages visited*, which provides an indication of the amount of potentially relevant information that students view, these effects turn out to be even stronger than the complementary effects of print reading proficiency, accounting for navigation. In the case of the other two indices that focus more on how often students opened and re-opened pages, there were still effects on digital reading performance independent of print reading proficiency, but these were smaller; and in these analyses, print reading proficiency proved to be the comparatively stronger predictor.

This means that the more *relevant pages* students visit, the better they are likely to perform. This effect cannot be explained solely by the fact that students who display better navigational behaviour are also those with better print reading proficiency. On the contrary, although students with better print reading skills display better navigational behaviour in terms of the number of relevant pages they visit (*number of relevant pages visited*), and the number of times they access relevant content (*number of visits to relevant pages*), navigation is associated with digital reading performance in ways that are independent of print reading proficiency. This supports the notion that proficiency in digital reading cannot fully be mapped according to traditional print reading proficiency.

Non-linear effects of navigation on digital reading performance

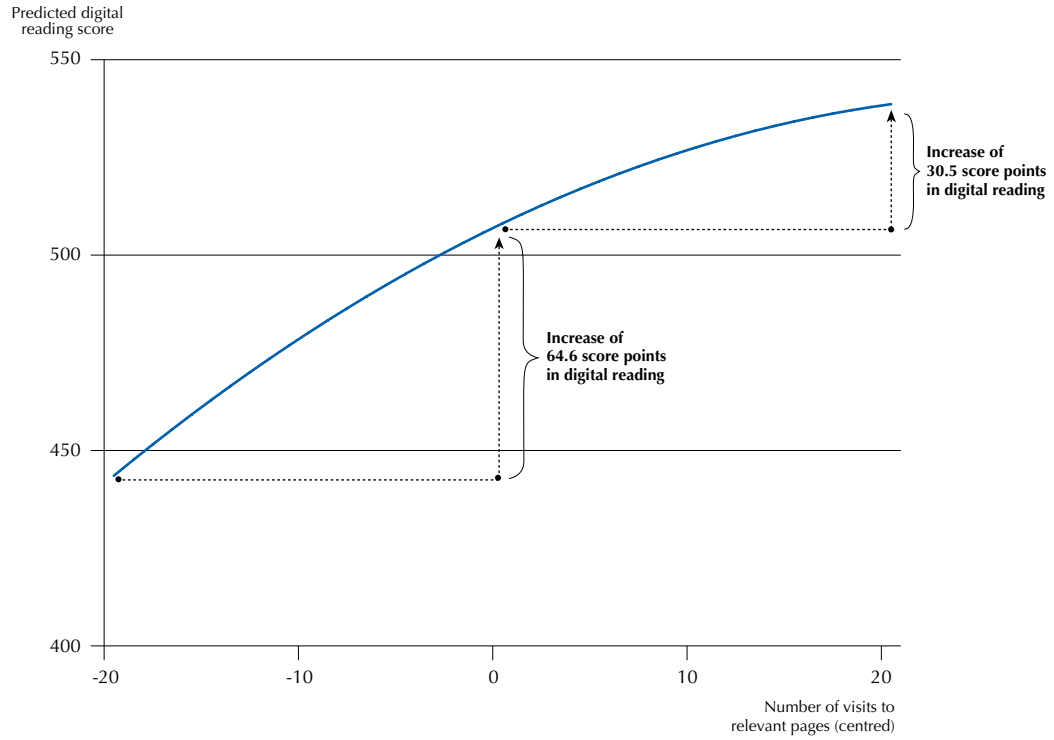
Indices capturing the extent of actions students take when performing digital reading tasks, such as the *number of visits to relevant pages*, or the *number of page visits*, have overall positive linear associations with performance (Tables VI.3.2, VI.3.5, and VI.3.6). However, a linear model might not be the best way to describe these aspects of the relationship between navigation and performance. Consider, for example, the *number of visits to relevant pages*. Clearly, a student who rarely visits relevant pages will most likely fail in a given task and achieve a low score on the entire test. In contrast, a student who has a moderate number of visits to relevant pages will probably fare better. However, visiting relevant pages more often than is needed, meaning that these pages are revisited frequently, might have an additional beneficial effect on comprehension if done thoughtfully, as a result of proper monitoring and regulation of the comprehension process (see also the case study of Item 2 in the unit *JOB SEARCH* below). In many cases, clicking back and forth between pages is a sign of disorientation, rather than of proper monitoring and regulation, as is indicated by negative associations of high numbers of backtrack-sequences of the type $Page_A - Page_B - Page_A$ with learning outcomes reported in the literature (Richter, *et al.*, 2005; Savayene, *et al.*, 1996).

To test for non-linear effects of navigation on digital reading performance, the previous section's regression models, which predicted digital reading performance by print reading and navigation, were extended. In addition to the linear effect of navigation on digital reading performance, a non-linear (quadratic) effect of navigation on digital reading performance was estimated. Inspection of the regression coefficients revealed that non-linear effects were present for both the *number of visits to relevant pages* and the *number of page visits* consistently across countries (Tables VI.3.7 and VI.3.8).

For the *number of visits to relevant pages* and the *number of page visits*, the regression coefficient for the non-linear term was negative in each case. This indicates that, in each country, visiting yet another (relevant) page becomes less predictive of digital reading performance, the more visits to relevant pages students had already made. Averaged across all participating OECD countries, the predicted digital reading score for a student with 20 fewer visits to relevant pages than the average is 64.6 score points below the score predicted for a student with an average number of visits to relevant pages. In contrast, for a student with 20 more visits to relevant pages than the average, the predicted increase in digital reading score is only 30.5 score points (Figure VI.3.8). Overall, in conventional terms for effect size classification, the non-linear trends for both the *number of visits to relevant pages* and the *number of page visits* correspond to a medium-sized effect.

■ Figure VI.3.8 ■

Relationship between the number of visits to relevant pages (centred) and digital reading performance, OECD average



Source: OECD, *PISA 2009 Database*, Table VI.3.8.
StatLink http://dx.doi.org/10.1787/888932435397

In contrast to the *number of visits to relevant pages* and the *number of page visits*, for the *number of relevant pages visited* no consistent non-linear trend can be observed (Table VI.3.9).

Thus, for the indicators that load heavily on how often students visit any page, there is a point beyond which visiting more is not helpful. In contrast, for the *number of relevant pages visited* the relation with performance is linear. Taken together, these results suggest that once students have adequately covered all the relevant material, either visiting relevant pages more often or visiting more pages in general (relevant as well as irrelevant), tends not to provide any additional benefit.

Navigation and gender

Analyses presented in this chapter thus far provide evidence that navigation is related to digital reading performance, before and after accounting for print reading proficiency. At the same time, correlations exist between navigation and print reading albeit smaller. Chapter 2 shows that the gender gap found in print reading is also found in digital reading, however, the difference is smaller here, and after accounting for their print reading skill, boys tend to have a slight advantage over girls in digital reading. A similar pattern holds for navigation: In general, girls navigate better than boys. Overall, they visit more relevant pages (*number of relevant pages visited*), and tend to visit relevant pages more frequently (*number of visits to relevant pages*). For the *number of relevant pages visited*, girls' advantages are significant for 14 OECD countries (Table VI.3.1). Insignificant differences are found in Chile and Japan, and all three partner countries and economies. For the *number of visits to relevant pages*, significant advantages for girls are found in 10 OECD countries. Averaged across all participating OECD countries, girls visit more relevant pages (*number of relevant pages visited*), and more frequently (*number of visits to relevant pages*). These differences are not too surprising, given that the *number of relevant pages visited*, but also the *number of visits to relevant pages* are strongly correlated with digital reading performance, and girls do better

digital reading than boys. However, when print reading proficiency is accounted for, these advantages for girls are diminished, or even reversed. After accounting for print reading skill, significant differences in favour of boys are found in Chile, Spain and Poland, as well as in the partner countries and economies Macao-China and Colombia. This means that in these countries and economies, of boys and girls with similar print reading proficiency, boys will visit more relevant pages. A similar result emerges for the *number of visits to relevant pages*. On this index of navigation, after accounting for print reading proficiency, significant differences in favour of boys are found in Spain, France, Korea and Poland, and all four participating partner countries and economies. Also, averaged across all participating OECD countries, after controlling for print reading proficiency, boys display a significantly higher *number of visits to relevant pages*.

Taken together, these results are consistent with the assumption that the comparatively smaller advantage of girls over boys in digital reading as compared to print reading might be due to the fact that boys, who are on par with girls in print reading, tend to navigate slightly better. One should, however, bear in mind that *unconditionally*, girls are not only better readers than boys, but also navigate more proficiently in the electronic environment.

The analyses provided so far in this chapter underscore the importance of navigation for the comprehension of digital text. In particular, strong correlations between digital reading performance and the *number of relevant pages visited* were found, indicating that careful and comprehensive selection of task-relevant materials within a hypertext is one variable closely tied to digital reading proficiency in general. These associations are largely independent of students' print reading proficiency. Although the data provided here cannot ascribe causality, the statistical dependency of digital reading performance on navigation appears not to be a mere by-product of students' print reading proficiency. Rather, for two students with the same print reading proficiency, different digital reading scores are predicted, depending on how much of the material considered relevant to a given task they access, and depending on how often they access relevant pages. Some conclusions might also be drawn concerning different aspects of navigation, and their respective associations with digital text comprehension as assessed by the PISA digital reading assessment. Generally, it appears crucial that students systematically assess what they need to see in a hypertext and then access these materials. Doing more than that – visiting a lot more pages than required – apparently has no additional positive association with digital reading proficiency.

CASE STUDIES: NAVIGATION BEHAVIOUR OF STUDENTS IN SELECTED DIGITAL READING TASKS

The remainder of the chapter presents case studies of the navigation behaviour observed among students for six individual tasks from three units used in the PISA 2009 digital reading assessment: *IWANTTOHELP, SMELL* and *JOB SEARCH*. The case studies illustrate how some of the findings in this chapter operate at the task level.

The units used in the PISA 2009 digital reading assessment were designed to vary considerably in the complexity of text processing and navigation demands. The six tasks analysed in these case studies were chosen to illustrate this variety. The analysis describes a range of strategies used by students in response to these different task demands. It identifies behaviours that are associated with students who show higher digital reading proficiency, and other behaviours that are associated with students who show lower proficiency. This analysis offers a sense of the range of strategies used by good readers and by less effective readers. These strategies vary from task to task, as do the specific questions investigated.

To date, empirical studies of readers' navigation behaviour in individual reading tasks have mostly been conducted on a small scale (Barab, *et al.,* 1996; Madrid and Cañas, 2008; McEneaney, *et al.,* 2009; Puerta Melguizo, *et al.,* 2008; Rouet, 2003). The PISA 2009 digital reading assessment allows for a large-scale examination of students' navigation behaviour in response to a variety of individual reading tasks by analysing the log files that capture every navigation step made by students as they respond to each task, as well as the time they spend on each page.

Data of this kind allow for analysis of the different kinds of behaviour students exhibit when confronted with different tasks. It is possible to observe how much exploration stronger and weaker readers typically engage in when confronted with new reading stimuli, as well as the extent to which this level of exploration varies according to the demands of individual tasks. It is also possible to observe under what circumstances readers avoid visiting pages not obviously relevant to the task, and when, by contrast, they are more likely to explore the available material. The analysis allows for a consideration of the value of categorising students according to the behaviours referred to earlier in this chapter as "knowledge seekers", "feature explorers" and "apathetic users" (Lawless and Kulikowich, 1996).

The case studies provide evidence of specific navigation sequences, including when better readers decide to visit specific pages multiple times, and when they deem a single visit sufficient. They describe navigation behaviours typically employed by weaker readers and contrast these with behaviours of better readers. Information is provided about the activity of students who fail to gain credit or to provide responses to particular questions, for example, how much navigation (if any) they engage in, and whether or not they locate all the relevant pages. The case studies also show the amount of time students spend on tasks with differing demands, and on pages containing information necessary to answering the question. The behaviours of students who answer questions successfully and unsuccessfully are compared. Differences in patterns of navigation behaviour between girls and boys are described. For example, the analysis provides evidence of how far it is true to say that boys are likely to engage in more navigation (that is, to click on more links) than girls. The analysis focuses mainly on digital reading performance, but when relevant, comparisons between performance by different sub-groups in digital and print reading are also examined.

The main aim of these case studies is to investigate patterns of behaviour observed when students perform individual reading tasks. The aim is not to report on navigation indices, as the first section of this chapter does, nor to relate these patterns to performance on the digital reading assessment as a whole. Rather, the case studies show the demands made by individual tasks, and the patterns of navigation behaviour used on these tasks by stronger and weaker readers. Therefore, the tables presented in the remainder of this chapter draw on somewhat different data and use different analyses from the statistics used in the other chapters and PISA 2009 volumes.

In this section, all figures relating to the numbers of students refer to those for whom log-file data are available, from all countries and economies that participated in the digital reading assessment. They may differ slightly from absolute numbers of students attempting each task. Group sizes are often too small for meaningful analysis at the country level; as a result, the analysis in this section is at the level of the whole sample of students to whom each task was administered. Scale scores are given to indicate the difficulty of each task; in addition, percentages of students in different score categories (full credit, partial credit, no credit, no response given) are provided to facilitate comparisons between different types of behaviours and the various sub-groups within each score category.

Although the tables in this section refer to similar measures referred to in the first section of this chapter, the *number of relevant pages visited, number of visits to relevant pages* and *number of page visits* are reported in absolute numbers in this section. For some tasks, additional counts are also presented: *number of pages visited, number of irrelevant pages visited* and *number of visits to irrelevant pages*. These are not analysed as indices, generalisable across the entire digital reading assessment, but are related to individual tasks. They are presented in absolute terms, not centred or standardised. Because the behaviours are identified according to issues relevant to individual reading tasks, rather than associated with framework variables or patterns of performance by country, the analyses present unweighted numbers (to illustrate the absolute frequency of particular behaviours), percentages of students, and unweighted mean scores.

Tasks analysed in the case studies

Figure VI.3.9 lists the six tasks analysed in Chapter 3. As described at the beginning of this chapter, the pages that students can view in the course of each task can be categorised as *necessary* (that is, the pages students need to visit to locate the information required to answer the question), *relevant* (pages that may or may not be essential, but contain useful information that may assist students), or *irrelevant* (pages that contain no information that will assist students in completing the task successfully). The sum of all pages that students can view, by using all links and tabs, represents the number of *available* pages. Figure VI.3.9 summarises features of the task related to navigation and text processing: the number of pages of each type, and an indication of the quantity and complexity of the text students need to process. It also shows the percentage of students who obtained credit, the mean time spent by all students on each task, and the average number of pages visited by students during each task.

Figure VI.3.9 shows that, for example, in *IWANTTOHELP* Question 1, students can locate the necessary information on a single page (that is, the starting page for the task) containing only a small amount of simple text. This is the only relevant page for this task, although there are 31 pages available to students during this task if they decide to explore all the possibilities. The task is relatively easy (digital reading scale score 362). The mean time spent on the task is 66 seconds, and the mean number of pages visited by each student is 1.6. Other tasks require students to visit two, three or more pages, each containing text of varying lengths and complexity.

The section at the end of Chapter 2, comprising examples of the PISA 2009 digital reading units, provides a detailed description of all the tasks in each of these units. They can be viewed on line at w*ww.pisa.oecd.org*.

■ Figure VI.3.9 ■

Summary of characteristics of digital reading tasks analysed in this section

	Task features					Student response				
	Navigation			Text processing		Performance	Behaviour			
Task	Necessary pages[1]	Relevant pages	Available pages	Quantity of text	Complexity of text	Digital reading scale score	Time on task (seconds)		Number of pages visited	
							Mean	S.D.	Mean	S.D.
***IWANTTOHELP* Question 1 E005Q01**	1	1	31	Short: one short text (less than 200 words)	Low level: simple. informal language	362	66	41	1.6	2.1
***IWANTTOHELP* Question 2 E005Q02**	2	2	31	Short: two short texts (essential information is in 50-word text)	Low level: simple, informal language	417	39	29	2.4	1.8
***IWANTTOHELP* Question 4 E005Q08**	5 or more	13	31	Long: multiple texts, each with multiple sections	High level: some formal text, some technical language, relatively unfamiliar situation	Full credit: 567 Partial credit: 525	183	123	11.2	8.8
***SMELL* Question 1 E006Q02**	2	2	13	Medium: set of six search results, plus relatively long text (230+ words)	Medium-high level: some dense text, popular scientific language, familiar topic	572	88	49	2.4	2.4
***SMELL* Question 3 E006Q06**	3	3	13	Long: multiple texts of varying lengths (longest is 400+ words)	Medium-high level: some dense text, popular scientific language, familiar topic	485	85	51	4.1	3.9
***JOB SEARCH* Question 2 E012Q03**	3	4	8	Medium: multiple short texts	Low: mainly informal language, personal, familiar topic	Full credit: 624 Partial credit: 462	153	81	5.5	4.4

1. Including the page where the task starts.
Source: OECD. *PISA 2009 Database.*
StatLink http://dx.doi.org/10.1787/888932435397

The number of available pages in each task is relatively modest. This restriction was a deliberate decision made by those who developed the test: it was seen as critical that students were presented with a set of tasks they could reasonably be expected to complete in the available time, in order to allow an adequate assessment of their ability to respond to these tasks. Another consideration arose as the test was developed: students need guidance in locating the information necessary to answer the questions. There is no value in including tasks where large numbers of students become disoriented, confused and frustrated because they cannot locate the necessary pages. The result is that some of the tasks provide explicit directions about links to click on and pages to visit. Others are somewhat less explicit, since it was considered important to assess the extent to which students were able to locate necessary information by themselves. As indicated by the substantial amount of variation in the navigation indicators *number of relevant pages visited* and *number of visits to relevant pages* (Table VI.3.1), students did differ in the degree to which they visited pages containing necessary information. These issues, concerning available material and explicitness of guidance, play an important role in students' ability to navigate in the digital medium.

Each of the case studies that follow starts with the task that students see, followed by a set of questions to be explored, a description of essential features of the task, and a list of the necessary pages (pages that students need to visit in order to locate the information required to respond successfully to the task). Since each task raises different issues, the discussions that follow vary.

IWANTTOHELP

IWANTTOHELP – *QUESTION 1*

Read Maika's blog entry for January 1. What does the entry say about Maika's experience of volunteering?

Questions for this task

This is the first task in this unit, and therefore lends itself to consideration of how much students explore when presented with new stimuli. Although the task requires no navigation and there is little text that students need to process, they have the opportunity to investigate numerous links, both within the website of the starting page (Maika's Blog) and within another website accessible from a hyperlink on the starting page.

- What proportion of students visited pages not necessary for answering the question?
- Is increased navigation associated with higher digital reading performance?
- Are there differences in the patterns of navigation used by boys and girls?
- Are any observed gender differences associated with differences in reading performance?

Essential features of the task

The context for this unit is a blog for Maika, who is interested in doing volunteer work. This is a relatively simple task, requiring students to read one short, simple text. The instructions direct them to look only at the text at the top of the open page, making a literal match between the date in the question and in the heading for Maika's blog entry, "Tuesday, January 1". No navigation is needed, as the task directs students to read only this page and the information required to answer the question can be seen on this page without scrolling.

When students start this unit, two tabs are open: the active (visible) tab, Maika's Blog (P24), and a second one, *IWANTTOHELP* (P01). Students may click on the other available tab, "iwanttohelp.org" (P01), or on the link in Maika's Blog that goes to the same page. There are several other links available on Maika's Blog, leading to additional pages, but none of them is relevant to this question.

This was a relatively easy question (digital reading scale score 362), with over 84% of students receiving credit (Table VI.3.10). The mean digital reading score for students who answered unsuccessfully was low (385 for girls, 317 for boys), and even lower for the small proportion who did not attempt the question (306 for girls, 287 for boys).

Necessary page

- P24[4]: Maika's Blog Home page

Exploring

Overall, few students engaged in much exploration in this initial task in the unit: 83.5% of students did not go beyond the page that is open at the start of the task, the only page relevant to this task.

Boys (19.3%) were more likely than girls (13.7%) to visit one or more pages other than the starting page (Table VI.3.11). There was no difference in the mean proficiency level of boys viewing only the starting page compared to those visiting multiple pages. However, girls who did no navigation beyond the starting page had a higher mean score (508) than those who visited two or more pages (493).

Exploration of the available links and pages for this task, where there is only one relevant page, is not generally indicative of the behaviour of good readers, consistent with what has been described above. The great majority of students who obtained credit successfully found the answer by reading the starting page, with no further navigation (70.8% of all students). The pattern that emerges beyond this is that as the number of pages visited increases, the mean ability of the students diminishes (Table VI.3.12).

In terms of *number of page visits*, when all students obtaining full credit are examined as a group, there is very little difference in digital reading proficiency among those who visited only the starting page where the necessary information can be found (519), or made three page visits (520) or five page visits (523) (Table VI.3.13). When girls

and boys are considered separately, however, a slightly different picture emerges. The girls with the highest reading proficiency for both digital (526) and print (530) were those who visited *no* pages other than the starting page. Those making three or five page visits had slightly lower scores, though the difference is not significant. The boys with the highest mean reading score in both digital (524) and print reading (508) are the small group who made five page visits (2.1% of all boys). Their score for digital reading is similar to those with three page visits (521), but considerably higher than for those boys who visited no pages other than the starting page (511). It seems, then, that while most students, both boys and girls, do not engage in unnecessary navigation, small groups of good readers do choose to explore the available navigation space. This provides a qualification to the suggestion by Lawless and Kulikowich (1996) that so-called "feature explorers" tend to demonstrate lower performance in reading tasks.

The small proportion of students who visited two pages (that is, only one page other than the Necessary page) had a much lower reading ability in both digital and print reading, similar to those who visited 10 or more pages. In most cases the second page visited was the other available tab ("iwanttohelp.org"), which contains no information relevant to the task. It seems that these students were pursuing no clearly directed activity and did not actively explore the available content, since they went no further than the single extra page. Minimal undirected exploration seems to be a behaviour characteristic of less proficient readers. It may be that a single cursory click on an additional page is a mark of confusion or uncertainty, whereas students who explore further are taking the trouble to satisfy themselves that they have found all the relevant information, or at least determined that they do not need to continue with lots of additional page visits.

There is a suggestion from the navigation patterns for this task that, in general, the more proficient readers assess the task requirements and adapt their navigation behaviour accordingly. Where no navigation is required, the better readers tend not to engage in navigation that appears irrelevant. There are, however, small groups of good readers who do actively explore a number of pages; boys with good reading ability are slightly more likely than girls to do this. This exploration may result from the fact that this is the first time students have encountered this set of material, and their exploration is intended to give them a sense of the overall context and scope of the kind of material that is available.

SUMMARY

- Students most commonly acted strategically for this task, using the task directions and remaining on the starting page, where the target information is available.
- Few students engaged in lots of exploration ("feature explorers"), but those who did explore tended to perform better if they engaged in a relatively thorough fashion.
- There is some difference in the navigation behaviour of girls and boys. The highest-performing (and largest) group of girls did not go beyond the starting page, while for the highest-performing group of boys (a very small group), the optimum number of page visits was five. This suggests that for those boys (and to a slightly lesser extent, girls) who deem it important to explore the site, this is a useful strategy. This exploration may be more relevant in the first question in the unit (first encounter with the stimulus) than in later questions.
- A single click on an irrelevant page, with no follow-up, is characteristic of lower-proficiency students, and does not seem as effective as either remaining on the single relevant page or more thorough exploration.

IWANTTOHELP – *QUESTION 2*

Go to Maika's "About" page.

What kind of work does Maika want to do when she leaves school?

Questions for this task

The main issue for this question relates to the behaviour of students who did and did not visit the target page where the information can be found.

- What proportion of students visited the target page, Maika's "About" page, P25?
- What proportion of students gained credit for the task without visiting the target page? What evidence is there that these students guessed?

- What behaviour is most commonly associated with students who received no credit?
- Is there evidence of students seeking but failing to find the target page?
- Are any gender differences associated with any of these patterns?

Essential features of the task

This task requires students to follow a link on the starting page to a second page (P25). Identifying the link relies on making a literal match with the task wording. Once students find the target page, the text is very short. The task is relatively easy (digital reading scale score 417), with just over 76% of students answering it correctly (Table VI.3.14).

Necessary pages

- P24: Maika's Blog Home page
- P25: Maika's "About" page

Guessing

This task requires students to click on a link from the starting page (the Home page for Maika's blog, P24) to Maika's "About" page, P25, in order to find the answer. The data show that the great majority of students (almost 80%) visited this page (Table VI.3.14). Those who did not visit the page would have had to guess an answer, unless they had already visited the page while answering Question 1, and remembered the answer. Using their memory in this way is likely to be a mark of a good and careful reader, and the data do not support the notion that they were good readers relying on their memories: the small percentage (3.9%) who received full credit but did not visit P25 had a much lower reading ability than those who followed the link to P25. This suggests that they did in fact guess. Boys (4.9%) were slightly more likely than girls (3.0%) to guess.

Of the 79.8% of all students who did visit P25, about 90% received credit (credit: 72.6% of all students; no credit or no response: 7.2% of all students). About two-thirds of those who received no credit (including students giving no response: 16.3% of all students) also failed to visit P25. Boys were slightly more likely than girls not to visit P25, and this is reflected in their performance on the task as well as in their overall reading score.

Efficiency of navigation

For students receiving credit for this task, those who followed the most efficient navigation path, clicking directly and only on P25, Maika's "About" page, had a substantially higher mean digital reading score (532; see Table VI.3.14) than those who visited additional (irrelevant) pages (mean digital reading score = 512). The strategy of "knowledge seeking" appears most suitable here. This finding is in line with the negative quadratic trend found for the number of page visits in relating to digital reading proficiency, as described in the section "Non-linear effects of navigation on digital reading performance".

Of those requiring multiple clicks to locate P25, 358 students (1.6%) required five or more clicks to reach the page, and a further 189 students required four or more clicks to locate it, suggesting they had some level of difficulty in this access aspect of the task. A small number of students (86) seem to have become lost, visiting five or more pages, but not finding P25. These students had a low mean reading ability (448), similar to those who did find P25, but answered incorrectly.

SUMMARY

- The overall picture that emerges here is that most of the difficulty in this task consisted in following the task instructions and finding the correct page, using a literal match; the text processing task, once they had found the page, was relatively simple.
- A small but significant minority of these students also visited one or more irrelevant pages. This irrelevant navigation was associated with students of lower proficiency, suggesting that it was counter-productive. In contrast to the first question in this unit, exploration seemed to be no longer of value.
- About 20% of students did not visit the critical page, and there is evidence that they guessed. A very small proportion of students engaged in a lot of navigation, but did not find the critical page. It seems that careful attention to the demands of the task might assist here.

IWANTTOHELP – *QUESTION 4*

Read Maika's blog for January 1. Go to the iwanttohelp site and find an opportunity for Maika. Use the e-mail button on the "Opportunity Details" page to tell Maika about this opportunity. Explain in the e-mail why you think the opportunity is suitable for her. Then send your e-mail by clicking on the "Send" button.

Questions for this task

This task allows for an investigation of how students deal with the demands of a complex task requiring a combination of multiple navigation steps and integration of information from multiple texts. There are numerous pages available, necessary, relevant and irrelevant, as well as directions in the task that assist students in navigating efficiently. This task offers the best illustration, among the six tasks analysed, of the variations in navigation behaviours that students exhibit.

- How much time did students typically spend on this complex task, and how many pages did they typically visit? How wide was the variation in these behaviours?
- What evidence is there that exploration of the available space is typical of higher proficiency students in this kind of task?
- What proportion of students followed the most efficient pathways? How did use of these pathways relate to overall proficiency? What evidence is there of inefficient navigation?
- What navigation behaviours were used by students who received no credit or gave no response for this task? Did they locate the critical pages? Did they engage in much irrelevant navigation?

Essential features of the task

This is the final question in this unit. It is a complex task that requires students to follow a series of links to locate one or more volunteering opportunities. They need to use information given on the page where the task starts, Maika's Blog, in selecting a suitable opportunity from the four possibilities. They then need to write a short explanation for their selection and send it as a message. There are two suitable opportunities, and students gain credit for selecting and justifying the choice of either one. There are 31 pages available for them to navigate to in total, of which 13 are relevant; they need to visit a minimum of five pages to provide a valid response to the question.

Slightly over 42% of students (46.7% of girls; 37.9% of boys) obtained full credit (digital reading scale score 567) for this question (Table VI.3.15). Some 14% obtained partial credit (digital reading scale score 525), while fewer than 5% answered the question but obtained no credit. The number of students giving no response was especially high for this item (around 40%). The high non-response rate may be attributable in part to the multiple demands, including navigation, of this complex task.

Necessary pages

This task offers a range of necessary and relevant pages, depending on evaluations students make. There are two equally short possible navigation paths that students can follow in order to obtain credit, described below as Pathway A and Pathway B. Each of these pathways involve visits to five pages.

Pathway A

1. P24: Maika's Blog Home page
2. P01: iwanttohelp Home page
3. P02: Latest opportunities
4. P04: Graphic Artist opportunity details
5. P08: E-mail this Opportunity to a Friend (Graphic Artist)

Pathway B

1. P24: Maika's Blog Home page
2. P01: iwanttohelp Home page
3. P02: Latest opportunities
4. P07: Upway Primary School – Work with kids opportunity details
5. P11: E-mail this Opportunity to a Friend (Upway Primary School – Work with kids)

Students may complete the task successfully, and obtain credit, by using either Pathway A or Pathway B, but they more often visit at least seven pages, including the two expected additional pages described below:

Expected additional pages

6. P35: Edit or Send your message (Graphic Artist)
7. P12: E-mail confirmation: "Your message has been sent successfully."

OR

6. P36: Edit or Send your message (Upway Primary School – Work with kids)
7. P12: E-mail confirmation: "Your message has been sent successfully."

Students may obtain credit for having completed the reading task if they omit these two final steps; that is, they receive credit for finding a suitable opportunity and giving an explanation relating to its suitability even if they do not send the information in an e-mail message as directed by the task.

The full list of 13 relevant pages is shown in Figure VI.3.10.

■ Figure VI.3.10 ■

Relevant pages for *IWANTTOHELP* – Question 4

Page ID	Page content
P01	*IWANTTOHELP* Home page
P02	Latest opportunities
P03	FAQ
P04	Graphic Artist opportunity details page
P07	Upway Primary School – Work with kids opportunity details
P08	E-mail this Opportunity to a Friend (Graphic Artist) page
P11	E-mail this Opportunity to a Friend (Upway Primary School – Work with kids)
P12	E-mail confirmation: "Your message has been sent successfully."
P24	Maika's Home page
P25	Maika's About page
P26	Maika's Contact details
P35	Edit or Send your message (Graphic Artist)
P36	Edit or Send your message (Upway Primary School – Work with kids)

Source: OECD, *PISA 2009 Database*.
StatLink http://dx.doi.org/10.1787/888932435397

Time spent on this task

This complex task required a lot of time (Table VI.3.16). The mean time spent on this task, for all students, was slightly over three minutes, the longest of any of the tasks presented in this chapter, although some other tasks in the PISA 2009 digital reading assessment required a longer average time. Students gaining full credit spent on average closer to four minutes; even those giving no response to the question spent on average around two minutes on the task. There is a correlation of 0.33 between time on task and score (Table VI.3.17).

Number and relevance of page visits

The mean number of pages visited by students obtaining full credit was 8.2 although students who gave a response made, on average, slightly over 13 visits to pages in total (Table VI.3.17). Some students made many more page visits than this, however: the maximum was 125 (Figure VI.3.11). There is a correlation of 0.32 between number of visits to pages and score (Table VI.3.17). The relatively high correlation of ability with pages visited (0.52) and with number of relevant pages visited (0.63) is consistent with what has been described in the first part of this chapter: students who visit only relevant pages tend to be better readers than those who explore all available material, including multiple irrelevant pages.

Table VI.3.17 shows that students receiving full credit, although they visited a similar number of pages (both number of pages visited and number of page visits) to those receiving partial credit and no credit, tended to visit fewer irrelevant pages than either of those groups: an average of 0.8 irrelevant pages visited and 1.2 visits to irrelevant pages. As students performed better on this task, they tended to make more relevant page visits, and fewer irrelevant page visits.

In contrast, students who obtained no credit visited, on average, 3.7 irrelevant pages and made 5.1 visits to irrelevant pages. This means that these students were wasting a substantial proportion of their extensive navigation activity on irrelevant pages that would not provide information useful for completing the task. Students who gave no response to the task still engaged in a significant amount of navigation, visiting, on average, 6.6 pages in total, most of which were relevant.

Variation by country

Since this task is the most complex, in terms of navigation, of those analysed in this chapter, it is worth considering variations among countries in the time spent as well as the number and relevance of pages visited (Table VI.3.18). Countries' mean scores on this task were generally closely aligned with their overall means on the digital reading assessment, with only Denmark (performing considerably more weakly on this task) and France (performing considerably more strongly) showing much variation between their mean score on this task and their mean digital reading score overall. Students in northeast Asian countries spent the most time on this task: Japan (mean of 254 seconds, a little over 4 minutes), followed by Macao-China, Hong Kong-China and Korea (241, 238 and 223 seconds, respectively). In contrast, several European countries spent the least time: Austria, Hungary and Iceland (139, 151 and 155 seconds, respectively).

For most categories of potentially useful navigation (number of pages visited, number of relevant pages visited, number of visits to relevant pages and number of page visits), east Asian countries tend to have the highest means, consistent with time spent on task, although their rank order varied somewhat. Students from the partner economy Hong Kong-China tended to visit the most pages in total (17.6), followed by the partner economy Macao-China (16.8), Korea (16.2) and Japan (15.0). For total relevant page visits, the rank order was Hong Kong-China (14.4), Korea (13.5), Macao-China (13.0) and Japan (12.5). The number of relevant page visits showed some variation from this pattern, however, with Korea, the highest-performing country, having the highest mean (7.1), followed by New Zealand and Japan (6.3), then Hong Kong-China (6.2) and Australia (6.1); these were the five countries with the highest overall means for digital reading, as well as the highest average numbers of relevant pages visited overall (Table VI.3.1).

In contrast, students in Colombia, Chile and Austria visited far fewer pages: 4.1 pages in Colombia and 5.1 pages in Austria and Chile. Similarly, pages visited and relevant page visits were also significantly lower in these countries: Colombia (3.3 relevant pages visited, 5.4 relevant page visits), Chile (4.2 and 6.9, respectively) and Austria (4.3 and 6.9, respectively).

Students in the partner economies Macao-China and Hong Kong-China had the highest number of visits to irrelevant pages (irrelevant pages visited: 2.0 and 1.8, respectively; total irrelevant page visits: 3.7 and 3.2, respectively), followed by Korea and Japan (2.7 and 2.5, respectively). The country with the fewest irrelevant pages visited was Australia (0.6), followed by Norway, Iceland, New Zealand and Ireland (all 0.7). Students in two of these countries also visited, on average, less than one irrelevant page in total: Norway 0.8, and Australia 0.9. Means of students in Iceland and Ireland (1.0) and New Zealand (1.1) were only marginally higher.

Initial navigation sequences

Students had four options to choose from. Pathways A and B, described above, led directly to the two opportunities suitable for Maika. Parallel pathways for may be described as Pathways C (for "Vegfest") and D (for "Help fix up Twin Falls Track!"). These seem efficient, but both could be eliminated on the basis of information provided in Maika's Blog, which states that she is looking for a longer-term opportunity.

Substantial numbers of students who were awarded credit followed Pathway A or B as their initial navigation sequence (Table VI.3.19). Student gaining full credit had somewhat different overall proficiency scores according to which of these pathways they chose. Those who began with Pathway A (13.9%) had slightly higher reading proficiency (577) than the mean of all students at each score level; those who began with Pathway B (only 1.3%) had significantly lower mean scores (535). For students awarded partial or no credit, the mean score of those starting with Pathway A was significantly higher than for Pathway B (and for Pathway C or D).There are several possible reasons for choosing Pathway A: Maika's Blog notes that she wants a longer-term position, and the "Graphic Artist" opportunity is "ongoing"; Maika's "About" page refers to her interest in web design, which allows the inference that a "Graphic Artist" opportunity is likely to be relevant to her; and this is the first opportunity in the list.

Students who received no credit rarely started with either of the most efficient navigation sequences. Only nine students began with Pathway A, and a single student began with Pathway B. This contrasts with 3 333 students (15.2%) who were awarded full credit, and a further 902 (4.4%) who were awarded partial credit, who began with Pathway A or B.

Few students who were awarded credit (15 students in total: 8 with full credit, 7 with partial credit) began with Pathway C or D. In contrast, only 18 students who were awarded no credit began with Pathway A or B, whereas 260 (1.2%) of those students began with Pathway C or D (mean scale score = 462). In all, 4 263 students (19.3%) embarked on and followed Pathway A or B within four steps of starting their navigations for the task, and the great majority were awarded credit. In contrast, 275 chose Pathway C or D, almost all of whom were awarded no credit.

This suggests either that better readers begin with more efficient navigation pathways, or that students benefit from starting their navigation pathways in the right direction. The data do not allow any clear view on which of these is more likely; but a close reading of the information presented on the first pages students are likely to see, the table summarising opportunities, and the information given in Maika's Blog identifying information that is relevant to the reading task, would seem to improve the likelihood that students set off on a suitable path, and may reduce the likelihood that they become confused or frustrated as a result of lengthy and unhelpful navigation.

Inefficient navigation

Although many students began their navigation with the most efficient pathways (A or B), the majority did not, whether or not they were awarded credit (Table VI.3.19). This is perhaps surprising, since the task directions, which state the purpose of the task, would tend to direct students to one of these efficient pathways. Nevertheless, there is no significant difference between all students who obtain full or partial credit and those with the same credit level who began with Pathway A. It seems that students will choose a variety of pathways, not necessarily the most efficient, to successfully reach the same end.

The concern, however, is less with those who did obtain credit than those who performed poorly. Many students who gave no response failed to locate necessary pages (Table VI.3.20). Some 4 475 students (about 20%) who gave no response visited four or fewer pages, whereas the minimum sequence needed to obtain credit is five pages. The table shows a clear link between the number of pages visited and mean ability, in both digital and print reading. Those who did not move beyond the starting page had a (low) mean score of 350 for digital reading and 396 for print reading. This may be a sign of disengagement in the task. At the other end of the spectrum, those who visited 11 or more pages (2.3% of students with no credit; 8.1% of students who gave no response), had much higher mean scores for digital reading, even though they received no credit. Their scores were similar to those among students who received no credit (467) and among students who gave no response (463). It seems that many students navigate a great deal to no effect.

Variations in individual student behaviour

Figure VI.3.11 gives a sense of the range of time taken and pages visited by individual students. The time spent for an answer receiving full credit varied from as little as 46 seconds to 1 511 seconds (over 25 minutes), with visits to pages varying between 5 and 125. The persistence of this student paid off, as he received full credit and also managed to complete all items in the assessment.[5] One girl who obtained full credit spent 1 000 seconds (nearly 17 minutes) on the task, visiting 24 pages in the process. This was clearly an ineffective strategy, as she failed to complete 6 of the 19 items in the test, a factor that would have contributed to her relatively low digital reading score (360) compared to print (407). Some students who received no credit, or gave no response, spent similar or even longer times on the task.

A few students (four girls and five boys) who were awarded full credit visited only the minimum number of necessary pages (five). Others, regardless of their score on this task, visited many more than this. In contrast, another student, despite visiting 85 pages, ultimately gave no response to the question. His digital reading score (220) was much lower than his print score (429). In this case, facility in clicking on links was not associated with reading effectiveness in this medium.

This wide variation offers a good illustration of the highly disparate ways in which students construct their own texts as part of the process of responding to the task (see the discussion at the beginning of this chapter). Figure VI.3.11 provides a powerful indication of the extent to which students also vary in their ability to know what to do in the digital medium. This task offers a maximum of 31 available pages. Every page received at least 100 visits from students, while the average number of visits to each irrelevant page was 1 962 (data from 22 036 students were collected for this task).

■ Figure VI.3.11 ■

Extremes of student behaviour for *IWANTTOHELP* – Question 4

Score	Time on task (seconds)	Gender	Country	Digital reading score	Print reading score	Number of pages visited	Number of relevant pages visited	Number of visits to relevant pages	Number of irrelevant pages visited	Number of visits to irrelevant pages	Number of page visits	Number of items not reached	Number of items reached, with no response	Comment
Full credit	1 511	boy	New Zealand	469	458	24	11	91	13	34	125	0	0	Most page visits (boy)
	959	girl	Norway	427	374	16	10	62	6	18	80	0	6	Most page visits (girl)
	697	girl	Hong Kong-China	582	587	9	9	58	0	0	58	0	2	Most pages visited, all relevant (girl)
	565	boy	Ireland	484	437	9	9	51	0	0	51	0	2	Most pages visited, all relevant (boy)
	548	girl	Colombia	502	506	15	12	43	3	5	48	3	0	Equal highest number of unique relevant pages visited (all)
	1 000	girl	Colombia	360	407	8	7	18	1	1	19	6	2	Longest time for full credit (girl)
	46	girl	Korea	473	505	7	7	7	0	0	7	0	0	Shortest time for full credit (girl)
	47	boy	New Zealand	305	403	7	5	5	2	2	7	5	8	Shortest time for full credit (boy)
	121	girl	Iceland	688	694	5	5	5	0	0	5	0	0	Equal fewest page visits for full credit (girl)
	160	girl	Poland	620	589	5	5	5	0	0	5	0	0	Equal fewest page visits for full credit (girl)
	254	boy	Belgium	601	547	5	5	5	0	0	5	0	0	Equal fewest page visits for full credit (boy)
	222	boy	Japan	517	494	5	5	5	0	0	5	0	0	Equal fewest page visits for full credit (boy)
Partial credit	722	boy	Macao-China	498	513	18	10	45	8	55	100	0	0	Most pages, most irrelevant pages, partial credit (boy)
	939	boy	Macao-China	394	270	21	12	49	9	44	93	0	1	Longest time for partial credit (boy)
	638	girl	Austria	502	568	10	9	64	1	3	67	0	0	Highest total relevant page visits, partial credit (all)
	573	boy	Hong Kong-China	422	536	26	12	41	14	23	64	0	1	Most unique pages visited (all)
	973	girl	Macao-China	394	446	17	9	30	7	22	52	0	3	Longest time for partial credit (girl)
	29	boy	Ireland	455	424	7	7	7	0	0	7	0	0	Shortest time for partial credit (boy)
	38	girl	Australia	532	512	7	7	7	0	0	7	0	0	Shortest time for partial credit (girl)
	313	girl	France	548	502	5	5	5	0	0	5	0	1	Equal fewest pages visited for partial credit (all)
No credit	639	boy	Korea	394	324	20	7	40	13	45	85	0	2	Most page visits for no credit (all)
	868	girl	Austria	383	385	11	4	10	7	26	36	0	4	Longest time for no credit (girl)
	1 192	boy	Hungary	302	509	11	7	16	4	5	21	0	5	Longest time for no credit (boy)
Missing	1 058	boy	Sweden	220	429	20	8	43	12	42	85	0	4	Most page visits, no response (boy)
	840	girl	Macao-China	334	366	12	5	21	7	39	60	0	2	Most page visits, no response (girl)

Source: OECD, *PISA 2009 Database*.
StatLink http://dx.doi.org/10.1787/888932435397

The 31 pages in this task represent a miniscule proportion of what is available in the real digital world. In that sense, the navigational demands of this task are far less than what readers may face as digital readers in their daily lives. Some students are capable of operating with great speed and effectiveness when presented with this kind of material, suggesting that they would easily cope with far greater demands. However, many other students appear to become disoriented, and to spend a great deal of time to little or no effect when presented with a reading task requiring them to synthesise information on one website in order to locate and evaluate information on a second website. This emphasises the need for clear guidance by teachers in how to approach reading tasks when students are required to use the Internet for seeking information, and when they are required to evaluate the available information. Simply sending students to the Internet without clear guidance is likely to be a waste of time and lead to frustration and poor learning.

SUMMARY

- This kind of task does not lend itself to a superficial approach. Good readers tend to visit as many pages as they deem necessary, with repeated visits, until they are satisfied with their answer.
- Patience with the complexity of the task is important. It is not generally possible to complete this kind of task adequately without devoting sufficient time to it.
- Many students appear to abandon early on any attempt to complete the task – among those who receive no credit, the fewer pages they visit, the lower their proficiency tends to be. This may be a sign of disengagement or frustration with the task, or of confusion about how to proceed.
- Careful reading of the information presented on the first pages is more strongly associated with students who receive credit. Simply continuing to navigate, without direction, does not appear likely to get students back on track.
- Many students do not navigate efficiently. The number of visits to irrelevant pages is high.
- Students need guidance in clarifying the task they face, in selecting relevant links and pages, and in avoiding irrelevant ones. This will improve the efficiency of their navigation efforts, reducing both the time and the effort they spend unproductively.

SMELL

SMELL – *QUESTION 1*

Go to the "Smell: A Guide" web page. Which of these statements best expresses the main idea on this page?

Questions for this task

This task allows for an investigation of how students react when presented with that commonest of digital texts, a set of search results. While the task directions are explicit, the possibility remains that students will explore, visiting pages that are irrelevant to completing the task. The text-processing demands of the task are considerably higher than the navigation demands.

- What proportion of students follows the most efficient (minimal) navigation pathway required for answering this question?
- To what extent do students explore the available pages?
- What differences are there between students who visit the target page, where the information necessary to answer the question can be found, and those who do not?
- What proportion of students guesses the answer to this question?
- How is time spent on the target page related to performance?

Essential features of the task

This question is the first in the unit. It explicitly directs students to navigate to the page, "Smell: A Guide" (P02), and identify the main idea of the text on this page. The question requires limited navigation. The starting page presents a list of six search results for the term "smell". Students need to select one link from the list (the first in the list) by making a literal match between the question wording and the search result. They then need to read the text on the page that opens in a new tab, scrolling down to read the entire text. Links from the search-results page to other pages allow a maximum of four tabs to open in this task: the "Global Search" (P01) page, plus the pages "Smell: A Guide", "Food in the news" and "Psychology Now". The links to the remaining three results lead to a page that states, "This page has no content available", and has a link back to the search-results page.

The text containing the necessary information is not short (over 230 words), relatively dense, and contains some terms commonly found in texts dealing with popular science. Students will typically need to spend a significant amount of time on this page; those who spend very little time on it are less likely to answer correctly. The task is relatively hard (digital reading scale score 572), with only 42.4% of students awarded credit (Table VI.3.21). The difficulty most likely stems from the need to read the text carefully, distinguishing between pieces of strongly distracting information (see Chapter 2, Examples of the PISA 2009 digital reading units), rather than from navigation demands.

Necessary pages

- P01: Global Search results
- P02: Smell: A Guide

Navigation to the target page

Students who visited P02 had much higher overall reading proficiency than those who did not, whatever their score for this question (Table VI.3.22). Almost all students who visited this page also responded to the question: only 0.8% gave no response.

Guessing

Those who did not visit P02 would have had to guess. In all, 18.6% of students guessed their response (Table VI.3.22). This type of information is not available in print-administered assessments. If a large proportion of students guessed correctly, this would undermine confidence in the assessment, but few of these students (fewer than 5% overall) were awarded credit. Among students receiving credit, there is a large difference in digital reading ability between those who *did* visit P02 (552) and those who *did not* (456). In all score categories, students who visited the necessary page show higher proficiency than those who did not. For those receiving credit, girls (39.8%) were more likely than boys (34.3%) to visit the page rather than guess, and a similar pattern was observed among those who attempted the question but received no credit. This again underscores the importance of learning how to search for relevant information.

Time spent on the relevant page

Students who answered the question successfully spent noticeably more time on P02 (12 or 13 seconds longer, on average) than those who answered incorrectly (Table VI.3.22). Girls spent slightly longer on the page than boys. The very small proportion (fewer than 1%) who visited P02 but gave no answer to the question spent much less time on the page.

Good readers tend to spend sufficient time on the relevant page to read and locate essential information.

Exploring

This task does not invite exploring as some other tasks might. It starts with a list of search results, but the question explicitly directs students to visit a single page.

Table VI.3.23 shows figures for girls and boys who received credit for this question, according to the number of pages they visited, their digital reading score, and the time they spent on P02. The students with the highest mean ability are those who visited only two pages: the starting page and (in the great majority of cases) the target page, P02. Consistent with the demands of this task, the students who were awarded credit who visited only the necessary page were better readers than students who explored. This group accounted for one-third of all students, with girls (35.7%) more likely to follow this straightforward path than boys (29.1%). The lowest-performing group is composed of students who did not visit P02, but guessed correctly.

Students who visited between four and seven pages showed a higher level of proficiency than those who visited only three pages, or who visited eight or more pages. This suggests that many good readers make a deliberate decision to do a certain amount of exploring of the available material, but not too much. There is more evidence here of strategic behaviour by the better readers: a single click on one additional page will be insufficient for the good readers, among those who decide to explore the available pages, to be sure they have a good idea of the information that can be viewed; but they tend to be careful to limit their exploration and not waste time looking at a large number of pages. This finding corroborates the general trend showing that large numbers of page visits are not helpful, as indicated by the non-linear trends for the test as a whole.

In addition, students need to spend adequate time on the page where the target information is found, where there is a relatively long, fairly complex text to read, rather than click on other pages to see if they might provide useful information. More able readers act strategically, ensuring that they spend sufficient time on the target page, P02: around 80 seconds or slightly more, for most groups of both girls and boys. In contrast, those who visited three pages also spent the shortest amount of time on the target page of any sub-group (68 seconds on average, both girls and boys), and this is reflected in their (low) mean reading score.

Efficient reading

Most students visited P02 only once, suggesting that they did not feel the need or desire to explore the information available on additional pages that would most likely be irrelevant to the task. Behaviour seems to be influenced by the nature of the task, which is highly constrained, with explicit guidance on navigation.

Among students who were awarded credit for this question, any additional visits to P02 were associated with substantially lower proficiency for girls (Table VI.3.24). Among boys, there was not a large difference between those who visited P02 once and those who visited the page twice; lower proficiency was more marked for those who visited the page more than twice. The numbers making multiple visits to P02 were small, so caution is needed in drawing conclusions.

Among students who gained no credit for this question, relatively few visited the target page, P02, more than once. Here, boys who made two visits had higher reading scores than those who visited the page either only once or more than twice. This suggests that these students are engaged in the task, since they take multiple navigation steps, but they are unable to complete the reading task successfully. For girls, it seems that an increase in the number of visits to the page is equated with a reduction in reading proficiency. It is possible that students who make multiple visits to the page find the text-processing demands too great, and eventually decide to guess.

SUMMARY

- Navigating to the correct page more strongly suggests a good reader than guessing without reference to the critical material. There are no surprises here, but this analysis allows us to demonstrate that this is true.
- Those who find and view the material on offer, even if they don't read it carefully, tend to be better readers than those who do not visit the necessary page.
- The more proficient readers spend a substantial amount of time processing the necessary page, and do not waste too much time investigating irrelevant links or revisiting the necessary page. There is a suggestion that girls may be somewhat more likely to be "knowledge seekers" (Lawless and Kulikowich, 1996) than boys.
- Where the task is constrained, a focus on locating the relevant page and spending adequate time on careful reading, rather than exploring the available material, is typical of better readers. The most able readers are most likely to make a single, careful visit to the target page, rather than repeated visits interspersed with other exploration.

SMELL – *QUESTION 3*

There is information about the smell of lemon on the pages "Food in the news" and "Psychology Now". Which statement summarises the conclusions of the two studies about the smell of lemon?

Questions for this task

This task allows for an investigation of how students' ability to locate the necessary pages relates to their proficiency.

- What proportion of students visited the two necessary pages, P03 and P07?
- How do students visiting only the relevant pages compare with other students?
- What evidence is there that visiting additional pages is a sign of high or low ability?
- Is there evidence that some students engage in navigation but do not find the necessary pages?
- Is there evidence that very good readers might remember essential information from earlier visits to one of the necessary pages, thus obviating the need for them to visit that page again?

Essential features of the task

Students need to compare information on two pages, P03 (Food in the news) and P07 (Psychology Now), in order to identify a conclusion common to the information presented on both pages. The Food in the news and Psychology Now pages represent the kind of texts found in popular scientific online publications, with a strong commercial element. Students are likely to have already viewed and read P03, in the process of responding to the previous question (Question 2). Nevertheless, since the reference to the smell of lemon is not in a prominent place on P03, it seems unlikely that students would have remembered this detail sufficiently closely to answer this task with confidence.

As a result, they are likely to need to engage in scanning of both texts for information relating specifically to the smell of lemon. This task (digital reading scale score 485) was easier than Question 1 in this unit (Table VI.3.25), likely because of this need to focus only on specific information, and possibly because some of the material may by now have been more familiar to students.

Necessary pages

- P01: Global Search results
- P03: Food in the news
- P07: Psychology Now

Visits to necessary pages

The data show that when answering this question, the great majority of students (70.3%) visit P07, to which they had not previously been directed, and which was irrelevant to the previous tasks in this unit (Table VI.3.26). A smaller majority (56.9%) visited P03, to which they were directed in the previous question, while a substantial minority (28.1%) visited P02, the page required for the first question in the unit, but irrelevant to this question.

It may be assumed that students who did not visit P07 would have guessed, since it is unlikely that they had both visited P07 on one of the two previous questions in this unit and recalled accurately the information necessary to answer a question they had not seen.

Of the students who were granted credit for this question, those who followed the pathway as directed in the question, visiting only the two relevant pages, P03 and P07, had a digital reading ability (563) substantially higher than the mean for all navigation pathways (534) (Table VI.3.27). Their digital reading ability was also much higher than that of students who visited only P07 (526) or P03 (495). Not surprisingly, those who were granted credit who visited neither P03 nor P07, and who therefore would have had to guess their answer, had much lower mean digital reading ability (439). Mean ability was similar in print and digital reading for groups with these navigation patterns. These results provide no evidence that good readers rely on their memory for information viewed during previous tasks in this unit: the highest reading ability among those awarded credit is shown by those who visit both P03 and P07.

Of students who answered the question unsuccessfully, the largest group (10.5%) either guessed (most likely) or relied on their memory of visits during previous questions, although this is unlikely since they would only have viewed P07 as part of an exploration irrelevant to those questions. That is, they clicked on no links, and did not visit either of the two necessary pages while completing this question. These observations suggest that these students made no real effort to answer the question; they were "apathetic users", in the terms of Lawless and Kulikowich (1996). A slightly smaller proportion (8%) visited P07 but not P03.

It is clear from Table VI.3.27 that there is a relationship between the proficiency of students and the amount of relevant navigation they engage in, regardless of the level of credit given. Those with higher proficiency tended to visit both the relevant necessary pages; the next proficient are those who visited only P07, the page not needed in previous questions in this unit. Below them are those who visited P03, but not P07; and the weakest are those who did not navigate beyond the search results page displayed at the start of the question.

SUMMARY

- The majority of students visited the necessary pages, but a significant number did not, which required them to guess. Those who guessed were unlikely to receive credit.
- Students who restricted themselves to visiting only the two pages containing the necessary information tended to have higher reading proficiency.
- A significant minority of students visited a page relevant to an earlier question in the unit, but irrelevant to this question.
- It is clear that significant numbers of students are not able to navigate efficiently in a task of this kind, with specific and restricted navigation demands.

JOB SEARCH

JOB SEARCH – *QUESTION 2*

You have decided to apply for the Juice Bar job. Click on the link and read the requirements for this job. Click on "Apply Now" at the bottom of the Juice Bar job details to open your résumé page. Complete the "Relevant Skills and Experience" section of the "My Résumé" page by choosing four experiences from the drop down lists that match the requirements of the Juice Bar job.

Questions for this task

This task allows for the examination of how the number of visits to relevant pages relates to proficiency.

- Is a single visit to the page containing the necessary information (the job advertisement, P03) indicative of a good reader, or are multiple visits more likely to be a sign of good readers?
- Is there a single efficient pathway commonly used by better readers?
- Do students become distracted by irrelevant pages? What does this tell us about their reading ability?
- What behaviours are demonstrated in this task by weaker readers?

Essential features of the task

This question is an example of a task that requires several navigation steps, which are explicitly described in the task instructions. Students need to locate and use information from one web page to make four decisions on another page, by selecting from drop-down menus. It is therefore to be expected that many students will need to switch between these two pages, but there are numerous possibilities for variation in navigation pathways chosen.

The task instructions are explicit in directing students to the pages to be visited, and are intended to prevent students from getting lost. There are two necessary pages for this task: P03 (Juice Bar job advertisement) and P13 (Relevant Skills and Experience drop-down menus).

Students are directed to refer first to P03 for the job specifications, to inform their choices when completing the drop-down lists.

For *JOB SEARCH* Question 2, approximately 30% of all students received full credit (digital reading scale score 624); 40% partial credit (digital reading scale score 462); and 30% no credit, with approximately equal proportions producing a no-credit answer and giving no response (Table VI.3.28).

Necessary pages

- P02: Job Search: Current Job
- P03: Juice Bar advertisement
- P13: My Résumé

In addition to the necessary pages P02, P03, and P13, there is one additional page that is highly relevant but not, strictly speaking, necessary, as students may be already familiar with the term and concept of a résumé.

- P04: What is a Résumé?

Digital versus print reading

Those who were awarded full credit on this item have a higher mean score (by about 17 points) for digital reading (570) than for print reading (553) (Table VI.3.29). There is no substantial difference in the mean digital reading (506) and print reading (508) score of those with partial credit. Those who received no credit for this task tended to score about 20 scale points better for print than digital reading. Students who made no attempt to answer the question had an even larger difference (over 40 scale points) between mean digital (363) and print (409) reading scores. The patterns are similar for boys and girls.

This task requires students to locate two different pages and compare information on these pages. Since it was probably necessary to switch between the pages more than once, the navigation demand may be considered to be fairly high. It may also be considered to be representative of many real-life digital reading tasks, where multiple comparisons of information on multiple pages is required. The results here suggest that these kinds of navigation requirements allow good readers to perform better (that is, where the navigation demand is relatively high, the students who complete them successfully will tend to demonstrate higher reading proficiency in this medium), while adding to the difficulty of the item for weaker digital readers, that is, the reading ability that they demonstrate in print may not help them to achieve similar proficiency in digital reading.

Efficient reading

Students may read P03 once, or may switch between P03 and P13 a number of times. Many students (42.7%) followed the straightforward path, as directed in the task instructions (Table VI.3.30). Of these students, 13% received full credit, almost 20% received partial credit, and almost 10% were awarded no credit or gave no response. Girls were more likely (44.8%) than boys (40.7%) to follow exactly this sequence.

However, the 13% who received full credit using this navigation path are not the most proficient readers. Students following this navigation sequence and visiting no other pages have a mean overall test score no better, and in fact slightly lower (564), than the average (570), although this difference is only 6 points. A similar difference between overall and average digital reading score was observed with students who were awarded partial credit.

Students who visited only the necessary pages (the home page, P02; the job ad page, P03; and the résumé page where the drop-down menus are completed, P13), but made more than one visit to the page with the job advertisement (P03), showed higher overall proficiency, as measured by total test score, regardless of their success on this item, than other students (Table VI.3.30).

There is no evidence to support the idea that students who can remember what they have read on a single reading of a text are better readers than those who refer to the relevant pages enough times to make the numerous comparisons necessary. It seems that better readers tend to use more than a single visit, and do not rely on memory following a single reading. The navigation data show that of the students who scored full credit on this task, the higher their reading proficiency, the more they were likely to switch between the job advertisement page and the page where they completed the task of selecting relevant résumé experiences. As Table VI.3.31 shows, the girls with the highest mean proficiency were those who visited the page four times (2.5% of girls; mean of 598). For boys, the highest-performing were those who visited P03 four times or more (6.8% of boys; mean scores ranging from 580 to 588). This number of visits makes sense, given that there are four drop-down menus to complete. The résumé-completion task requires explicit comparisons of requirements in one text with a list of qualifications and experience in another. This sort of task lends itself to careful checking, so it is not surprising that repeated visits to the necessary pages were typical of the more proficient readers.

This is in keeping with the notion that in some tasks, the deliberate re-visiting of pages can be a good navigation strategy, as already outlined in the section "Indicators used to describe navigation". Here, revisits can be assumed to be helpful because not all the information required from a page can be memorised at once. Thus, while revisiting pages is often regarded a sign of disorientation and has negative associations with comprehension, there are examples where revisits are fruitful. This also means that task demands must be taken into account when analysing revisits as an indicator of navigation across different tasks.

Minimal reading

It is possible to get to P13 without consulting the Juice Bar job advertisement (P03), by ignoring the task instructions and the prominent hyperlink on the open Job Search page ("View details of job: Juice Bar Team Members"), and clicking instead on the link, "My Résumé". Some students by-pass instructions they may regard as intermediate, and navigate directly and swiftly to the final page, where the task is completed. They may not refer to critical relevant pages, but complete the task anyway. These students may miss crucial information, and therefore not gain maximum credit. Alternatively, they may be more interested in simply finishing the task without checking whether they have found and used (all) the available information.

Full credit can be received without referring to the job ad (P03), by inferring and guessing. Only 11.2% of students failed to visit P03 (Table VI.3.32). Boys (12.1%) were slightly more likely than girls (10.3%) *not* to visit this page.

The 150 students (0.7%) awarded full credit who did *not* visit P03 had a substantially lower level of reading proficiency (532) than those who did consult the advertisement (571), which suggests that guessing played a part in their responses. Similar differences in the overall level of reading proficiency between those who did and did not visit P03 were observed among students who received partial credit (509 v. 465) or no credit (434 v. 393).

Ineffective navigation

A number of students visited multiple pages, but did not find the critical page or pages required to complete the task. Those who engage in apparently undirected exploration are likely to be poor readers, and this notion receives some support in the data (Table VI.3.32). A small number of students (1.5%) who gave no response to the question visited at least three different pages, but failed to find P03.

Among students who answered the question, whatever level of credit they received, those who visited irrelevant pages showed lower reading proficiency than those who did not (Table VI.3.33), consistent with what was described earlier in this chapter. There is little difference in proficiency between those who visited only one irrelevant page and those who visited multiple irrelevant pages. The issue appears to be whether or not students visit *any* irrelevant pages: more able readers tend not to visit irrelevant pages.

A small proportion of students (2.1%) followed the minimum described sequence, visiting no other pages, but did not answer the question (Table VI.3.30); their mean digital reading score was 380, substantially higher than the mean of *all* students who gave no response (mean score of 363). They appear able to manage the navigation component of the reading task (locating the target pages), but unable to synthesise information from the two pages.

SUMMARY

The behaviour of students overall suggests various strategies used for this task:

- Students visiting the Juice Bar advertisement page multiple times tended to demonstrate the highest overall proficiency in the assessment.
- Students who did not visit the Juice Bar advertisement page tended to have the lowest overall proficiency. Better readers locate and use the information provided on this page.
- Students who visited no irrelevant pages tend to demonstrate higher reading proficiency than those who visited irrelevant pages.

The implication is that good readers are selective in the links they choose and do not waste time on irrelevant pages. This approach minimises the number of pages and amount of text they expose themselves to. They also take as much care as is needed in visiting and revisiting the pages with the information critical to the task, to verify that they have used it correctly. This task, which requires students to select only the most relevant information from a fairly long list of similar possibilities, demands careful integration of information across two texts. It is not surprising, then, that better readers tend to recognise the need to check that they have interpreted correctly all the demands of the task, and make the most suitable selection of résumé features.

CONCLUSIONS

This chapter has shown that successful reading in the digital medium requires effective navigation, and that it cannot be assumed that students can simply transfer reading skills learned in print reading to this medium. Effective navigation requires students to construct pathways to pages with information relevant to the task.

The overall picture that emerges from the case studies is that stronger readers tend to choose strategies suited to the demands of the individual tasks. Where no navigation is required (see *IWANTTOHELP* Task 1), better readers tend not to become distracted by the availability of irrelevant pages. Where the task requires them to compare information on different pages (see *SMELL* Task 3), the better students will locate these pages and navigate between them as many times as they feel necessary. When the navigation demands are complex (see *IWANTTOHELP* Task 4), better readers will spend more time on the task and visit more of the relevant pages than they do for simpler tasks. Better readers tend to minimise their visits to irrelevant pages and locate necessary pages efficiently. They also monitor their time, so that they are able to complete all the reading tasks in the time allocated.

There is evidence that when a set of stimuli is first presented to students (for the first question in a unit), a small percentage of stronger readers (boys slightly more often than girls) will explore the available navigation space (see *IWANTTOHELP* Task 1). This is not common behaviour; but for those who select and engage in it as a deliberate strategy, exploring to discover the range of available information, there is no indication that it impedes their likelihood of performing well. Good readers are expected to use a variety of strategies.

In contrast to careful, deliberate exploration, there is evidence that minimal exploration, such as clicking on a single additional page, but without follow-up, is an ineffective digital reading strategy (see *IWANTTOHELP* Task 1, *JOB SEARCH* Task 2). Navigation needs to be carefully directed. Students who make many visits to irrelevant pages tend to be poorer readers, as do students who fail to locate necessary pages. There is some evidence to suggest that good readers are those who start the reading task with an efficient navigation path (see *IWANTTOHELP* Task 4).

The digital reading assessment necessarily presents extremely constrained options for navigation – far less than the almost infinite range of navigation possibilities readers face when they use the Internet, whether for personal, educational or occupational purposes (see discussion in *IWANTTOHELP* Task 4). Nevertheless, what does emerge from this analysis is that the tasks included in the assessment offer enough navigation and text-processing challenges to measure and describe the digital reading proficiency of 15-year-olds from the 19 participating countries. Indeed, the tasks, as a whole, allow analysts to discriminate successfully among students at all proficiency levels.

Although the navigation demands of the digital reading assessment are modest, many students find it hard to cope with them. Even when the guidance is quite explicit, significant numbers of students still fail to locate crucial pages. Thus teachers and policy makers should not assume that students can navigate successfully or methodically in the vast realm of possibilities that the Internet offers them. The digital reading assessment offers powerful evidence that today's 15-year-olds, the "digital natives", do not automatically know how to operate effectively in the digital environment, as has sometimes been claimed. Simply turning students loose in the digital medium, without clear direction, is likely to increase the risk that they will waste time, become frustrated, and fail to engage productively as readers.

Students should be encouraged to define their reading task before they start to navigate. They need clear purposes for reading, encouragement to clarify these purposes before embarking on navigating, and practice in evaluating and selecting both the links they choose to follow and the material they will then be able to read. They should learn to recognise and use whatever guidance is available to help them to locate relevant or critical pages. Before embarking on a navigation path, students should determine why they are reading and what information they are looking for, to reduce the likelihood that they will become disoriented or waste time by visiting irrelevant pages. To use navigational tools and features effectively readers need to exercise discrimination and critical reasoning. Once they have navigated to necessary pages, they should ensure that they spend sufficient time on these pages to process the critical information. When information is to be compared across pages, students should be encouraged to understand that more than a single visit to each page is necessary. Students should be encouraged to avoid undirected navigation – clicking on numerous pages in the hope that one of them might yield useful information. Given that digital texts are not limited in size and scope the way print texts are, students need guidance in judging how much time is enough to spend on a task and how much navigation is necessary. The Internet is an almost infinite space, and if students are to use it productively, they need strategies to direct their navigation choices.

Notes

1. As a result of a technical problem, data for page visits could not be collected with complete accuracy in all cases. This means that there are some minor inaccuracies in some of the figures provided for the numbers of page visits, or number of visits to relevant pages, which do not influence the overall picture of the results presented here. For the same reason, the figures are not always exactly aligned between the aggregated data and the case-study data presented in this chapter.

2. In case of heavily right-skewed frequency distribution, sometimes a logarithmic transformation is applied to the data to normalise the distribution before using the data in further statistical analyses, such as regression. As the skew was only moderate in the present case, this was not done. In the regression models reported in the next section, however, residuals were distributed normally (see *e.g.* Cohen, *et al.,* 2003).

3. The fact that the effect size f^2 for Korea is to some degree an outlier is partly due to the comparatively low overall proportion of variance explained by print reading and navigation together in this country, as f^2 for a predictor is given as:

$f^2 = \frac{\Delta R^2_A}{1 - R^2_{Tot}}$, where ΔR^2_A is the variance uniquely explained by predictor A, and R^2_{tot} is the total variance explained in the model. Thus, f^2 will not only increase as ΔR^2_A increases, but also as R^2_{tot} increases.

4. Each page within a unit is identified using the convention P plus a two-digit number (so, P01, etc.).

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