2018

Documenting Digital Problem Solving: Qualitative Results Strategies and Approaches for Digital Problem Solving

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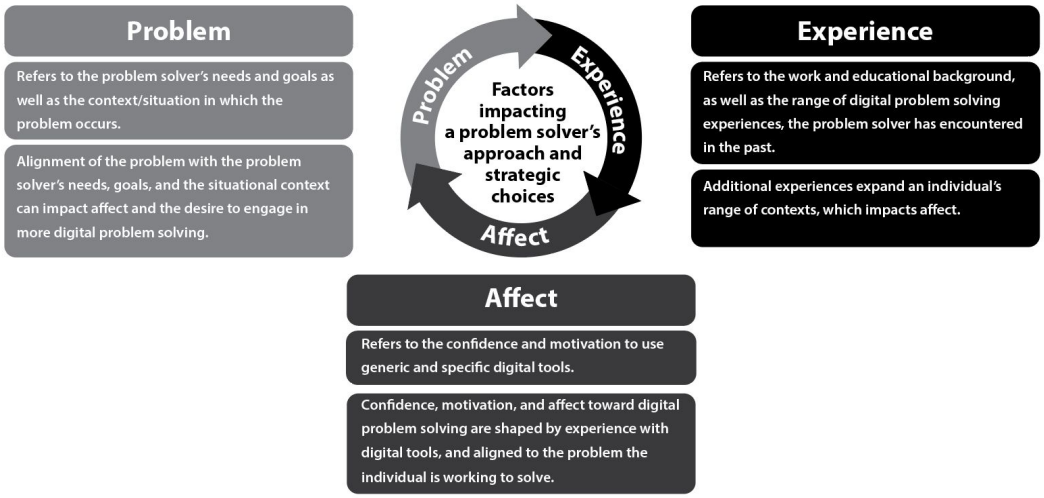
Strategies and Approaches for Digital Problem Solving

This mixed-methods research study examined digital problem solving strategies of 18 adults who ranged from novice to very experienced computer users. The research documented the digital problem solving strategies using a verbal protocol approach and analyzed to examine approaches. The tasks participants completed included the 9-item multi-stem PSTRE items from PIAAC and digital problem solving tasks in a library context the research team designed.

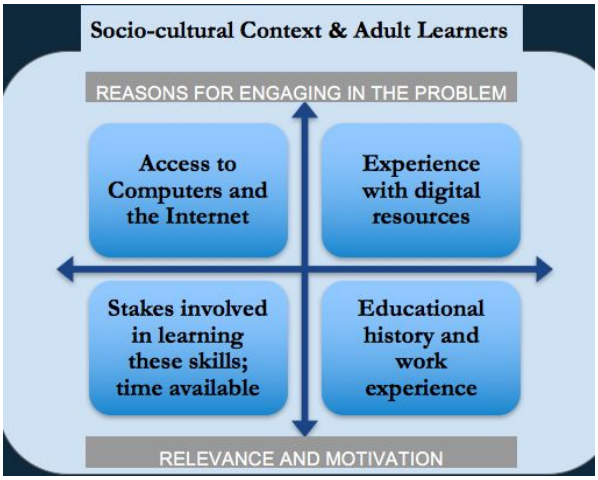
In analyzing the verbal protocols, a specific research team-designed coding scheme was used. The following operational definitions were central to coding and analyzing these qualitative data:

- **Approaches** are ways a person uses strategies.
- **Strategies** are cognitive tools used when a problem solver doesn't have the automaticity or skills needed to easily solve a problem or complete a task online.
- A problem solver's **approach and strategic choices** are impacted by 1) environmental & sociocultural factors, 2) the problem solvers' unique repertoire of experiences and affective concerns and 3) context/purpose for engaging in the digital problem solving event.
- A **problem solver's purpose** may be to achieve a result on an assessment task, or the application of digital problem solving in the context of real world activity. To be a, nimble problem solver, one must incorporate strategies flexibly, not just once but on a regular basis across contents and events.

A representation/synthesis of factors impacting a problem solvers strategic choices can be found below. This cycle of a progressively widening range of experiences as problem solvers engage in new problems in new events and in new contexts impacts the approach and strategic decisions of problem solvers.



All factors are impacted by the socioeconomic and cultural situation of the problem solver. Does s/he have access to both digital hardware and high speed internet? If so, is it at home or does s/he have to go to another location such as a library or school? Also, does the problem solver have access to learning opportunities and support around his/her digital problem solving?



Limited access to hardware and high speed internet interferes not only with a problem solver's opportunities to engage in this cycle, but limited access to educational opportunities around using digital tools does as well. These factors are not static nor independent of one another. Engaging in digital problem solving events contributes to the range of experiences of the problem solver as well as his/her confidence.

Scenarios of Problem Solvers

Here we provide scenarios of two different problem solvers. These scenarios are not meant to be generalized to all problem solvers. Instead they are meant to illustrate the differences between **more experienced** and **less experienced** problem solvers. Because problem solving is context dependent, how individual problem solvers move through a digital problem will necessarily differ. Furthermore, not all problem solvers will demonstrate all behaviors and may, in fact, demonstrate a mix of behaviors from the experienced and less experienced columns.

The more experienced problem solver. According to the list of contexts selected on the survey, Greg had the widest range of experience. When first attempting to problem solve in a digital environment, Greg worked systematically. He first took the time to understand what needed to be accomplished, then skimmed and scanned the interface and the resources available to him. For example, he looked at menus, icons, and read the onscreen text. As he worked, he checked his progress against his intended goal and adjusted his actions as necessary. When the digital interface did not look familiar or behave in an expected way or provide him with the expected results, he stopped and thought about what he already knew and what his past experience had taught him. He tried to use what he knew from prior experience, but when that was insufficient, he experimented with the interface. For example, he did not become flustered when he received an error message. Another time, when working with a spreadsheet, he tried different sorts in order to find the information needed. When those efforts did not provide him with

satisfactory results, he developed a work-around that would give him a result that met his needs. Greg needed support, however, in being thorough in his work. At times, he was eager to finish and missed key criteria within the problem.

Less experienced problem solver. According to the list of digital problem solving contexts, Paula had a limited range of problem solving experiences. Paula had worked in an office earlier in her life, but her experience predated the use of digital tools in offices. As she told us, she preferred doing things in person and did not see the need to use digital tools when she could accomplish things without them. Although she understood the basic goals of a number of digital problems presented to her (such as finding information within a spreadsheet), she struggled because she did not see the relevance of the tool nor did she understand the basic design and architecture of the tool. Because she had limited knowledge of the tools and resources, she needed guidance to know where to look and how to use them. She was hesitant to use the unfamiliar tools and resources and needed a great deal of reassurance before she would move forward.

THE ROLE OF CONTEXT

Our research has revealed the vital role of examining digital problem skills through a diversity of contexts. Different contexts require the use of different cognitive skills and strategies in different ways. Data suggest that the number, frequency, and complexity of contexts play an important role in how individuals engage in digital problem solving and the challenges and successes they experience.

Illustrative Example from Verbal Protocol Data

For example, one participant, Paula, had a limited repertoire of problem solving contexts, and was unfamiliar with dragging and dropping. She learned drag-and-drop through scaffolding provided during one of the tasks then applied it in later tasks. That problem solving experience, which broadened her range of experiences, as well as the access to the learning it provided, immediately impacted her problem solving by arming her with another tool (drag-and-drop) to utilize while problem solving. At the same time, Paula's limited range of experience in digital problem solving also impacted her choices.

The Digital Problem Solving Process

- The problem solver has to use different strategies to apply what they know to new situations.
    - Some strategies may be more effective than others and over-reliance on prior knowledge or prior experience online may in fact hinder problem solving. We observed that at times, problem solvers were not able or willing to let go of a strategy or approach that was not working simply because it had worked for them in a previous situation. Digital problem solvers need to be flexible and aware of when they should persist and when they should try another approach to meet their goal.

An example of a problem solver who had a limited number of contexts with which he was familiar was Dan. In one of the tasks we observed, Dan struggled to get the interface to behave the way he wanted it to

in order to solve the problem. He repeated the same series of actions that he knew from his previous experience a number of times, but he needed support to abandon that approach and try something new.

> *Dan: Let's see. So now I'm thinking of a way to get these into that little…[clicks back to "Word Processor" and points to the "Eligible Members Include" area with the cursor] into here. She wants the names. [right clicks (or maybe holds down shift and clicks) on name on spreadsheet and gets a menu from the computer including "copy" and "select"] Ahh, this is how i could have done it.*
> *Researcher: So tell me what you could have done. What are you thinking?*
> *Dan: I could have used this to select the numbers i wanted. [looks at submenu from the pop-up menu] I'm just seeing what's available.*
> *Researcher: Okay.*
> *Dan: [clicks off the page so the pop-up menu disappears] Try. i deselected that one. I'm hoping that i can select more than one. [gets the pop-up menu again]*
> *Researcher: So you're holding down shift and clicking the mouse hoping that you can select more than one?*
> *Dan: Right.*
> *Researcher: Is that working for you?*
> *Dan: [gets pop-up menu again] No. Hehe.*
> *Researcher: So this interface works differently than other interfaces you've been familiar with.*
> *Dan: [looks at menu options at the top of the screen] There's another way. [returns to clicking and getting pop-up menu three more times. Tries to click and drag a name higher on the list]] I'm trying to move it. But that doesn't work.*
> *Researcher: So why are you trying to move it?*
> *Dan: I was going to move him up here and put them all together, but that didn't work either.*
> *Researcher: Okay.*
> *Dan: I can try to copy. [right clicks on "Copy" button gets image options from the computer (copy image, view image, etc). Clicks on "view image". Then closes the pop-up window that followed. Right clicks (?) on top name on list and gets a pop-up menu]. Hm. Well at this point i'm feeling kind of lost. I'm not sure what i'll do here.*

In contrast, Greg, a participant with experience across a wide range of contexts, was persistent in solving the problem, but was able to let go of actions that were unproductive and was willing to explore the interface and experiment with new approaches. Even when the new approaches were unsuccessful, Greg was able to solve the problem to his satisfaction through a work-around or a "good enough" approach.

> *I'm trying to put a subfolder inside the Can Come for the rooms so that it makes it a little more organized. But it didn't seem like I can, but I probably can [opens up "New Folder" window again]. because usually people who are a little more thoughtful than myself come up with these things but I think that's also why I'm here.[creates another subfolder in the "Can Come" folder] No, it doesn't look like it's going to let me do that.[tries to open the "Can Come" folder again by clicking on the name] So. That sucks. But, um, life goes on.*

- Problem solvers may turn to a help menu, help function, tutorial, or a tutor or peer for assistance when they **need to clarify purpose/task**

In this example, Francis, a problem solver with a limited range of experience across digital problem solving contexts, is working with Carla, a problem solver with a mid-range of experiences across contexts. Carla served as a peer tutor to help Francis understand the task and work through the problem solving activity.

> *Francis: Okay, so what we do…[reads first email] So this one we need to put with "Can Come", right? And where's for the accommodations?*
> *Carla: Almost. So you're right about having to move these emails somewhere, but..*
> *Francis: The...okay.*
> *Carla: But we want to go back to the instructions where it says over here, "Set up your email folders to keep track of who needs accommodations" So if we want to set up a folder [motions toward list of folders with the cursor].*
> *Francis: See That's where I got yeah, yeah...chuckles*
> *Carla: Right, right. But it's not intuitive so it's okay you will learn with experience.*
> *Francis: So do we hit email?*
> *Carla: I'm not exactly too sure... [moves cursor over "Edit" then "File" options in the menu] Oh, But look! But if we just kinda look around [mimics the searching process through the menu options by running the cursor over the various options] we can find it and…[hovers over "New Folder" with cursor]*
> *Francis: New folder, yeah.*
> *Carla: Yes! New folder. So, let's see [plays with folder menu for a bit. Then returns to "New Folder" option.] What do you think we should name the folder?*
> *Francis: Accommodations.*
> *Carla: [pause] Sure.*
> *Francis: Or just put sure?*
> *Carla: No, no. So if we go back to directions it says, "Set up your folders to keep track of...who needs accommodations and organize these responses." So i think usually when people go somewhere they will either need a place to stay or they won't need a place to stay.*
> *Francis: Right, right.*
> *Carla: So that would be two different folders,*
> *Francis: Yeah*
> *Carla: You think?*
> *Francis: Yeah...Well, well, Not necessarily either, because not necessarily either. Because if they need accommodations they're going to say they need accommodations. So why would you put them in another folder the other ones that don't need accommodations, you're making more paperwork than you need...*
> *Carla: That's true. That's true. Do you maybe want to look through the emails and see what people are saying? To see...*
> *Francis: Okay.*
> *Carla:...if there are more specific things?*

- **Recognize that their strategy wasn't accomplishing the desired goal**

  In this example, Sonja, who had a limited range of contexts, and Ellen, who had a mid-range of contexts realized that they needed to experiment to complete the task because what they were doing was not achieving their desired goal.

  Ellen: Okay, "Number of Years as a Member"
  Sonja: And then you're going to secondarily search by the "Number of Rides"
  Ellen: Oh, okay. So that will organize them first by that. Okay cool.
  Sonja: I forget how many years. Four years you have to be a member.
  Ellen: Is that what it is? Four years...
  Sonja: Four and fifteen.
  Ellen: Four or more AND have participated in fifteen rides...
  Sonja: Yeah, So these are all eligible
  Ellen: ..four and fifteen rides
  Sonja: But it didn't seem to sort it well on the number of rides. Because it should -- let's try sorting it on number of rides this time.
  Ellen: And then maybe years as a member as the second one?
  Sonja: Yeah and see if that sorts better. I don't know why that didn't work right.
  [they apply the new sort criteria]
  Ellen: No it doesn't either.
  Sonja: Well, maybe number of rides we can just look at…
  Ellen: Yep.
  Sonja: Was it easier to look at it as years sorted and then mark the fifteen or highers? That was kind of easier on my eyes.
  Ellen: Fine
  Sonja: Yeah. Lets see. Years as a member. Number of rides.
  Ellen: Technically it should line up. But I don't know why it didn't work.
  Sonja: Like all the fours will be sorted?
  Ellen: Yeah. Now we frankly have to go manually through either starting down here or going up
  Sonja: It was fifteen, was it?
  [they then scroll through the spreadsheet marking people]

- **find the problem or task is outside the realm of their experience**
  Ron, a participant who had been living on the streets, was asked to work through a problem involving a spreadsheet containing a column of names along with columns of information about each individual. Ron was asked to identify those individuals who met a set of criteria. As he approached the problem, he appeared to have no sense of what the task was, how to approach it, nor what the criteria were. Our screen recording shows him randomly clicking the names. His actions, along with what he told us about his experience of working with digital tools leads us to posit that the task was so outside his experience that he went through the motions with no meaning. In order to problem solve, Ron needed a great deal of support from us.

- **lack the confidence to figure the problem out**
  Paula, a woman who had worked in an office before the emergence of computers, needed support or reassurance that what she was doing was correct. She had a general sense of the problem being solved and what was needed, but she had little experience with digital tools. She repeatedly asked, "Is this right?"

- **Flexible/intuitive/efficient problem solvers who have experience across a range of contexts are more likely to transfer what they learn as they move through a task to new situations within the task or different tasks.**

  - **Less experienced problem solvers** may need coaching and support in order to make this transfer
    When working on a problem that required the use of an online scheduling tool, Ned, who indicated he had a limited range of experiences across contexts, drew from what he learned from a previous problem and looked first at the bottom of the screen for an online calendar. When he was unable to find it, he needed to be directed to scroll bar, which then allowed him to find the calendar.
  - **More experienced problem solvers may be able to make this transfer of learning without support or with simple reminders**
    Greg, a participant who indicated he had experience across a wide range of comments described his problem solving approach in this way: "When I know there should be a way to figure it out and I can't figure it out, it'll bother more...more and more. It almost makes me anxious that I know I should be able to do this job but I can't. It's like when you're fixing your car and you watch the YouTube videos to be able to change your oil or do whatever, you get all the parts from the parts store, and for some reason it's just not working like in the video. I figure out another way because working stressed out is going to make me work less efficient."

Differences between more and less experienced problem solvers

More experienced problem solvers	Less experienced problem solvers
adapted to novel environments	struggled within novel environments
surveyed the resources available to them	tended to overlook many of the resources available or focus on the resources immediately apparent or those that are familiar to them
decided/figured out how to use resources to their best advantage	once aware of resources needed support to determine how to use them
used exploration/investigation to learn new approaches	were slow to examine what the resources and interfaces offer
let go of what they know (from previous experience)	relied heavily on approaches they know from past experience and resist trying new approaches
figured out what does not work through trial and error	were hesitant to try something different for fear of making a mistake, and they needed reassurance before trying something new

The Architecture of Digital Problem Solving Approaches and Strategies

How an individual uses different strategies is affected by how s/he approaches digital problem solving and the contextual factors within the digital problem solving task. Each problem solver, whether they have a wide range of experiences or a limited range of experience, will approach a problem differently and enact a strategy differently depending on context and experience. It is important to understand that the data show there is no one "right" way to digital problem solve. Instead, problem solvers draw on a range of experiences across contexts and at times an approach or strategy may help a problem solver achieve a goal and at other times the continued use of that approach and strategy might not be helpful.

There are four important aspects: systematicity, flexibility, persistence, and good enough

Systematicity: Moving through the task one step at a time. First taking the time to read through and understand the task, explore the interface and resources, check progress against the criteria.

> *Ned is systematic in that he carefully reads all the instructions, using the mouse to track his reading. He then explores the menus to see the options. He carefully reads before deciding what to do with it. He clicks the first in a series of choices, evaluates it, uses the back button, checks the next one. He clicks through to the provided options. He works reads in the incoming information and compares it to the task. He surveys the page to identify what the task is, scrolls through the resource to get a sense of how much data is there, then shifts determines what function within the interface to use.*

Less experienced problem solvers approached it more "randomly"; more experienced problem solvers had an internal checklist.

Flexibility: Switching strategies when what is being used doesn't work. Thinking creatively and developing workarounds when what you're doing isn't working as expected.

> *When the tool did not work as expected, Greg tried sorting in a variety of ways and then picked the approach that gave him a base from which he could figure out the answer without further use of the technology.*

Persistence: Doing the same thing over and over again even when frustrated or coming up with alternative approaches rather than becoming frustrated. Not being flustered by error messages or unexpected results.

> *Dan kept trying to use the right mouse button even though it did not provide him with the necessary tool for completing the task.*
> *Greg came up with a work-around rather than being frustrated by the task.*

Good Enough: Determining that the outcome of the problem solving process is sufficient given the individual's motivation, affect, prior knowledge, and context/purpose of the task.

More Persistence in problem solving	**Less Persistence in problem solving**
Sonja & Ellen played with the tool for a while before they decided their results met the criteria sufficiently.	*Ernie did the minimum necessary before moving on to the next task.*
Greg, after trying to create an embedded folder, says, "No, it doesn't look like it's going to let me do that.[tries to open the "Can Come" folder again by clicking on the name] So. That sucks. But, um, life goes on."	

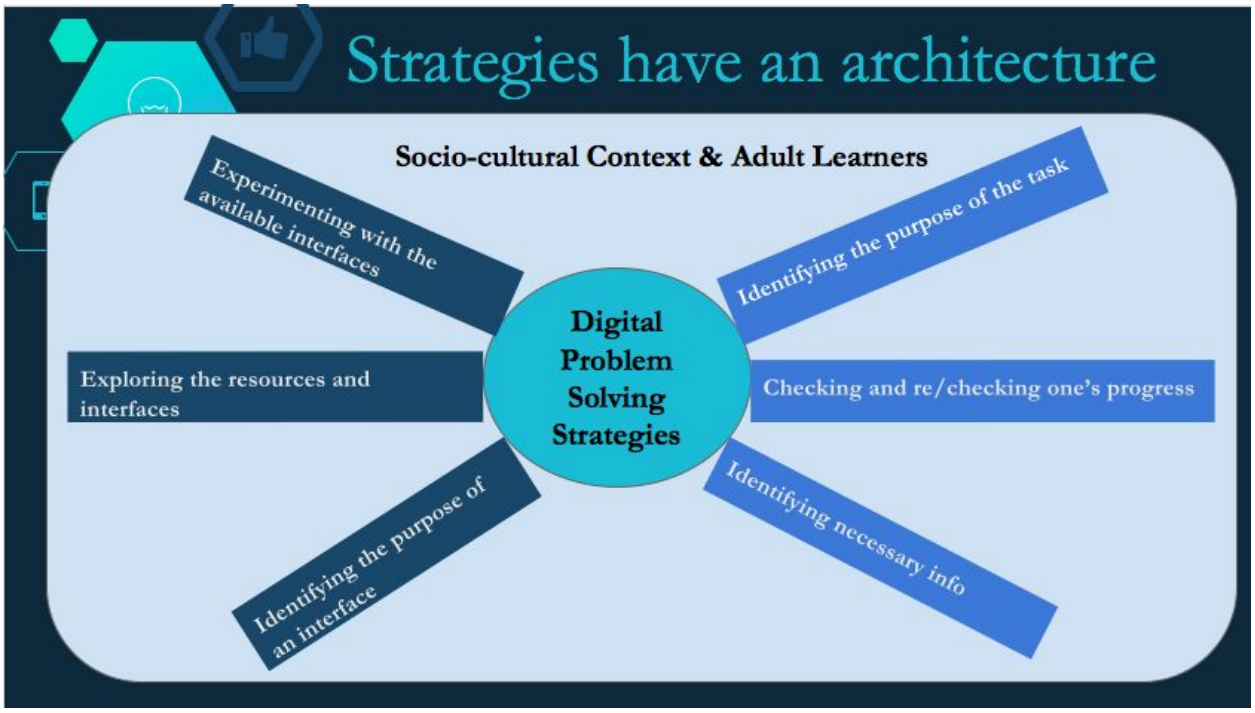
Digital Problem Solving Strategies

Data analysis revealed that digital problem solvers enacted six different strategies as they moved through an online task. This list is not necessarily inclusive of all problem solving strategies -- people in the field may see other strategies emerge.

The six strategies are organized into two sets: 1) information focused and 2) navigation focused.

The **information focused strategies** ask, do you you understand the purpose of the task, do you know what information you need, and are you accomplishing what you expected.

The **navigation focused strategies** ask, are do you understand the purpose or function of a digital interface, are you willing to explore the different resources and interfaces available to you and are you willing to experiment with the different digital interfaces to solve your task.



Information seeking strategies

The three information seeking strategies are (1) identifying information needed, (2) identifying the purpose of the task, and (3) checking and rechecking one's work. These three strategies may be enacted at any given time. For example, a problem solver needs to identify what information is needed and the purpose of the task as they set goals, but then they have to recheck the information needed and purpose of the task as they monitor their progress; plan their next steps; and acquire, evaluate, and use the information.

Identifying information needed

Choosing to ignore the information you don't need and focusing on what is needed. Doing this not only at the beginning but throughout the problem solving process. This is related to the strategy of checking and rechecking one's work. This is also related to the strategy of identifying one's purpose.

> *Greg describes doing this with the simple spreadsheet search. ('I really just glazed that over. I took in the information I knew I needed and then the rest of it just went "shwew", "shwew".')*

Identifying the purpose of the task.
Continually clarifying or specifying the purpose by reviewing the criteria on an ongoing basis. This is related to the strategy of identifying the information needed and can include checking and rechecking.

> *Ned needed support to navigate the interface, but seemed to understand the purpose of the task and how to determine what went where. He seemed to have an understanding of what is needed, but he needed support to move forward. He especially got lost when he needed to move between multiple screens. However, by the end of the task, he began to build an understanding of the different screens and was able to send out the complete one element of the task without prompting.*

> *Ernie realizes he doesn't have to copy and paste in the names and just click the names.*
> *[Rereads instructions from both Word Processor and Spreadsheet view]*
> *Ernie: Oh, I'm done.*
> *Researcher: Okay. What made you decide you were done?*
> *Ernie: I thought I could paste them in there. But you just had to mark them instead of…*
> *Researcher: Okay, great. So you had to go back to the instructions?*
> *Ernie: Yeah, I went back to the instructions like four or five times on that one.*

> *Paula is working on clarifying her purpose...with prompting she explains her confusions and receives scaffolding to work through it:*
> *She reading the task - silently - waiting for us to say something.*
> *Explore -- she went under the file menu -- to look at what was there.*
> *Prompt -- can you tell me what you're supposed to do.*
> *She notes - I need to organize these, but there seems to be something missing. Verbalized -- either said, I'm confused or I don't know what to do. When asked -- She seemed to have a sense of what she needed to do. She needed an other folder (or box). Not familiar with naming conventions or categories. She needed help refocusing on what the goal was.*

Checking and rechecking one's progress/work
Clarifying your purpose and examining the criteria against one's progress on the task. Making sure that you've accomplished your task.

> *Erin and Rebecca double checked their work before moving ahead. They first misunderstood that task and had to explore the task before determining they were done.*

> *When Sonja and Ellen are doing the complex email sort: After creating the folder and organizing the emails in the folders, the person with the mouse quickly looks back at the folders checking to see if the emails are in there. She quietly says, "Double check" as she clicks on them.*

Navigation Strategies
The three navigation strategies are (1) identifying the purpose of an interface or function of an interface, (2) exploring the resources and interfaces, and (3) experimenting with the interfaces. These strategies

build on the PSTRE technology dimension that includes hardware devices, software applications, commands and functions, and representations.

The three navigation strategies we identified do not represent a one-one alignment with the PSTRE technology dimensions. Instead, these three strategies may be enacted in order for the problem solver to make use of hardware, software, commands and functions, and representations (text, sound, numbers, graphics, videos).

For example, a problem solver needs to identify what resources and interfaces are available (such as a menu or a search bar when seeing information on a website, understand why a particular interface (such as menu or a search bar) is useful for solving a particular problem, and then be willing to try using the different interfaces (such as comparing the results from using a search bar versus what is found using the available menus).

Identifying the purpose of an interface or function of an interface

Based on prior experience and one's personal learning needs, or exploration and experimentation, understanding why a particular interface or function of an interface is used.

> *Sonja and Ellen knew they would need to do a sort as soon as they saw the spreadsheet.*
> *Sonja: (reading) "Respond to the secretary's note on the newsletter. Mark the members' names on the spreadsheet by clicking in the checkbox column."*
> *Ellen: (after reading from another place on the webpage) Ohhhhh, four years and fifteen rides.*
> *Sonja: Ohh, okay.*
> *Ellen: So we have to do some sorting on the spreadsheet.*
>
> *Ellen said that organizational tools such as email folders were a useful cognitive aid.*
>
> *Ned used search bars and menus to find what he needed within the library website.*

Exploring the resources and interfaces

Taking the time to look at the different resources and what the functions are within an interface before attempting to solve the problem or complete the task. When the current method isn't working, stopping mid-task to look at the resources and functions within an interface before continuing.

> *Before beginning the task, Carla showed Francis how to look at the different menu options and how things worked on a website.*

Experimenting with the available interfaces

Using the interface and functions in different ways to see how the output differs. Trying different functions to see which one would give the desired result.

> *Ned started to solve the problem by using menus then switched to doing a search when he couldn't find what he wanted on the menus.*

Suggested Citation: Castek, J., Jacobs, G., Gibbon, C., Frank, T., Honisett, A., Anderson, J., (2018). *Document Digital Problem Solving: Qualitative Results.* Advancing Digital Equity in Public Libraries: Assessing Library Patrons' Problem Solving in Technology Rich Environments.

The authors acknowledge contributions by Vailey Oehlke and Patricia Moran at Multnomah County Library, and Matt Timberlake at Multnomah County IT, members of the grant's advisory board as well as research collaborators Mei-kuang Chen, Stephen Reder, Andrew Pizzolato, and Laura Hill for their many contributions.