# Strategic Reading in Design Science: Let Root-Cause Analysis Guide Your Readings

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**Abstract.** Reading literature is important, but problematic. In Quora and other PhD forums, students moan about their frustrating reading and literature review experiences. Strategic reading might help. This term is coined to conceive of reading as a process of constructing meaning by interacting with text in a targeted way. The fact that strategic reading is purpose-driven suggests that the purpose might qualify the reading. If this purpose is Design Science Research (DSR), what would be the strategy for reading? Traditionally, students are encouraged to annotate while reading. Digital annotations are expected to be useful for supporting comprehension and interpretation. Our belief is that strategic reading can be more effective if annotation is conducted in direct relationship to a main DS activity: root-cause analysis (RCA). RCA can provide the questions whose answers should be sought in the literature. Unfortunately, this process is not supported by current tools. When reading papers, researchers might not be all aware of the issues being raised during RCA. And the other way around, when it comes to RCA, evidences found in the literature might not be promptly accessible. This paper reports on research to develop a technical solution to this problem: a plug-in for Google Chrome that provides seamless integration between the RCA platform (i.e. MindMeister) and the reading platforms (i.e. Mendeley). The aim: improving RCA awareness while reading so that annotations can be traced back to the RCA issues. First evaluations are positive as for improving reading focus and facilitating reference recoverability.

**Keywords:** Strategic reading · Root cause analysis · Mind mapping

## 1 Introduction

"Strategic reading" is a term coined to conceive reading as a process of constructing meaning by interacting with text [1]. While reading, individuals use their prior knowledge along with clues from the text to construct meaning, and place the new knowledge within this frame. Research indicates that effective or expert readers are strategic [2]. This means that they have purposes for their reading and adjust their reading to each purpose and for each reading task. The fact that strategic reading is purpose-driven suggests that the purpose might qualify the reading. If this purpose is


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Design Science Research (DSR), different questions arise: is there a DSR way of reading, are DSR researchers following it, how could DSR researchers be assisted to excel at strategic reading?

DSR has been defined as "research that invents a new purposeful artefact to address a generalised type of problem and evaluates its utility for solving problems of that type" [3]. Being problem-driven, DSR endows a preponderant role to root-cause analysis (RCA). DSR requires a profound understanding of the problem to be solved, the consequences to be alleviated, and the causes to be prevented. This in turn usually implies extracting evidence from the literature that warrants the project's RCA. We can then rephrase a key part of *strategic reading (in DSR) as the process of extracting evidence from the literature that sustains the project's RCA*. If a pivotal skill for researchers is that of asking the right questions then, we can conjecture that RCA could be the means to find these questions. We then conceive of RCA and reading as two inter-related processes which re-adjust and feed off each other: RCA progresses as new insights are obtained from the literature while the literature is scrutinised along the concerns that arise during RCA. This is not very far from linguistic theory, where writing and reading are regarded as partners in constructing meaning [4]. Here, we do not address writing but RCA can be regarded as the prelude to writing.

Unfortunately, this interdependency lacks appropriate support in current reading tools (e.g. Acrobat Reader) or reference managers (e.g. Mendeley, NVivo, or EndNote). What is needed is a way to bridge the gap between conceptualizing tools –where ideas are shaped and framed–, and reading tools –where ideas are sustained and opposed. We believe the challenge is not on leveraging existing tools, but on coupling tools with minimal interference with existing practices. What is needed is for tools to keep their autonomy, but interact with a double aim: (1) to guide reading (where reading purposes are to be sought in RCA), and (2), to draw on and document supporting evidence for RCA issues (where evidences are obtained from reading but used during RCA). These two flows are in overlapping motion: RCA concerns guide the reading while the reading comes up with new insights that confirm or refute the RCA issues. This work then addresses the following problem-based research question.

> *How can we provide seamless integration between RCA tools and reading tools to improve strategic reading for novice DSR researchers?*

If DSR is defined as "research that invents a new purposeful artefact" [3], this work resorts to a Chrome plug-in, DScaffolding, which bridges the gap between MindMeister (as the RCA tool) and Mendeley (as the reference manager). During reading, DScaffolding makes practitioners aware of the evidences being looked for ("the purpose pipe"). During RCA, DScaffolding makes researchers aware of the evidences that sustain/refute the causes/consequences in the RCA ("the annotation pipe"). DScaffolding is available for download at the Chrome Web Store (see later). Evaluation is being conducted with five PhD students.

## 2 Literature Review

### 2.1 Problem: Causes and Consequences

One of the most important skills for researchers to acquire is that of asking the right questions when accessing the literature [5]. The answers you get much depend on the questions you ask. This skill is especially important for PhD students, who struggle with an increasing number of papers and stringent PhD deadlines. Based on Mendeley data from 2008, PhD students were the main readers of articles [6]. This puts PhD students at the forefront of scientific literature consumption, even ahead of their supervisors! However, in Quora and other PhD forums, it is not rare to come across students moaning about their frustrating reading experiences (refer to [7] and its 54 comments). Causes can be multi-fold: lack of time (with increasing reading loads), lack of motivation (no prompt feedback from supervisors), reading considered to be an ancillary activity (as opposed to actually conducting the research), or lack of knowledge (not clear what to look for). If we focus on the latter, forums give some advice:

- "Before you start reading, have a clear idea of what information you are looking for in these papers. This by itself is about 60% of psyching yourself up for reading papers" [8].
- "Make notes of how the research in the paper you're reading connects with your own" [9].
- "Reading a scientific paper should not be done in a linear way (from beginning to end); instead, it should be done strategically and with a critical mindset, questioning your understanding and the findings" [10].
- "As you read, look for the author's main points. Generate questions before, during, and after reading. Draw inferences based on your own experiences and knowledge. And to really improve understanding and recall, take notes as you read" [11].
- "If you want to make it a productive exercise, you need to have a clear idea of which kind of information you need to get in the first place, and then focus on that aspect" [12].
- "When reading papers, it helps me to have a writing task so that I am being an active reader instead of letting my eyes glaze over mountains of text only to forget everything I just read. So for example, when I read for background information, I will save informative sentences from each article about a specific topic in a Word document" [12].
- "At the beginning, new academic readers find it slow because they have no frame of reference for what they are reading. But there are ways to use reading as a system of creating a mental library, and after a few years, it becomes easy to slot papers onto your mental shelves. Then you can quickly skim a paper to know its contribution" [12].

The underpinning assumption seems to be the existence of a "frame of reference". This frame serves to guide the reading, helping to provide "a clear idea of which kind of information you need to get in the first place". Strategic reading is then a distinctive feature of scientific reading, as opposed to let's say, playful reading, where the aim is

not to know the outcome, but instead to enjoy the poetic narrative and thrilling plot. To get the best of scientific reading, a frame of reference needs to be present.

This work addresses the case for Design Science Research (DSR). The first question is then how will a *"DSR's frame of reference"* look like. This paper's main assumption is that most of the readings during DS projects have (at least) five main foci, namely, (1) finding evidence for the importance of the problem, (2) ascertaining causal relationships in the problem, (3) becoming acquainted with works addressing similar problems, (4) becoming acquainted with work that can serve as a kernel theory or other inspiration, or (5) becoming acquainted with work relevant to research (method) design for the DSR project. RCA relates to the first two of these. We can then state **the problem** as:

**PhD students not bearing "the RCA frame" in mind when reading**

This might have a manyfold impact:

- Important facts might be overlooked when reading. This in turn, might involve a loss of opportunity for DSR projects. If not properly documented in the RCA, reading insights might be forgotten by the time they could impact the project's design, leading to overconfident problem analysis.
- Unfocused reading might result in boredom, lack of engagement and research effort discontinuity among PhD students.
- Literature references might not be traced back to their RCA rationales. This might cause poor reference recoverability when it comes to writing the paper, and hence, forcing re-reads.

So far, we can only hypothesise those consequences. Some studies exist on the impact of reading comprehension [13–15] but this is for settings other that scientific reading. We are unaware of any study that looks into those symptoms for PhD students. That said, the frequent recurrence of this issue in the so-called grey literature (e.g. Q&A forums), provides substantial evidence of the existence of this problem. As a case in point, refer to this Quora entry [9] with 774 followers. Causes include:

- No RCA frame available (yet). The importance of RCA in DSR projects cannot be stressed enough. This paper underlines its role as a reading guideline.
- A RCA frame is available but not easy accessible. Reading and RCA are conducted through different tools. So far, the coupling falls on the shoulders of the students through the use of book-notes and copying & pasting between the tools.

This work tackles the second cause. It is not uncommon for researchers to struggle with switching back and forth between e.g. Endnote and Word, to add notes. These approaches tend to be highly manual and error prone, even if conducted through state-of-the-art reference managers. In the end, keeping track of readings represents a considerable burden for students. We then refine the research question as follows:

**How can we bridge reading tools and RCA tools to ensure the presence of both RCA concerns when reading, and of reading evidences when conducting RCA?**

### 2.2 Meta-Requirements

Meta-requirements are generalised requirements for solving a general problem, in this case, bridging between reading tools and RCA tools (generally, regardless of which reading and RCA tools we're talking about). This section draws six meta-requirements for this bridging. For our purposes, "tool bridging" is not limited to piping data among the platforms but also includes extending participant platforms to collect/access this data.

**MR1: Provide support for setting reading purposes based on RCA issues**
For our aims, a "reading purpose" (hereafter, just "purpose") is an issue that has arisen during RCA (or other research concern, as described above) that needs to be tracked down during reading. This includes: finding evidence of the problem's consequences, ascertaining the causes (used to identify potential ways to solve the problem), looking into someone else's work to avoid re-inventing the wheel, and better assessing the distinctive contributions of the DSR project at hand. However, not all issues arising during RCA become a "purpose". RCA is a moving target. RCA is a gradual endeavour that builds up as better problem comprehension develops. RCA issues come up, disappear and receive different attention as the research progresses. Hence, not all issues should be addressed right away. Prioritisation is needed so that the most important problems are addressed first. Those issues that are not going to be the subject of the current investigation are left outside the reading radar and postponed to a later occasion. Researchers should be able to tick off which RCA issues become the current "purposes".

**MR2: Provide support for annotating literature resources as relevant to RCA issues ("the purpose pipe")**
The previous paragraph defines what a "purpose" is. Now, we tackle "resource" and "annotation". First, resources. The main resources are papers coming from the traditional research literature, particularly those available through reference managers. In addition, interesting insights might also be gained through the so-called "grey literature": blogs, product reviews, stakeholder comments, or Q&A forums might also sustain RCA. Most software practitioners do not publish in academic forums, which means that their voice is limited. Hence, the notion of "resource" refers not only to traditional papers but also extends to other Web resources.

As for annotations, they are typically used to convey information about a resource. Examples include a comment or a tag on a single web page, or a highlight upon a passage in a document. Traditionally, students are encouraged to annotate while reading. Digital annotations are expected to be useful for supporting comprehension and interpretation [16, 17]. But, how is annotation conducted? Our belief is that comprehension and meaning construction can be more effective if RCA reading purposes somehow "pop up" when annotating.

**MR3: Provide support for framing and incorporating annotations during RCA ("the annotation pipe")**
With current technology, annotations tend to be locked within a resource (e.g., a paper) itself or, at best, managed by a proprietary annotation repository (e.g. Mendeley). This hampers tracing annotations back to the purpose that triggered the annotation, which

hinders researchers from having a global view, not only of what they read, but also about the purpose of these readings. Meta-requirement MR3 mandates integrating annotations into RCA. Doing so should assist identifying which RCA issues have been overlooked (i.e. no annotations for these issues) and (thus far) lack appropriate literature evidence. Linking annotations to issues turns RCA diagrams into a kind of index to literature references.

**MR4: Interoperability: The exchange of annotations between reference managers and RCA tools should be facilitated**
The previous requirements introduce two pipes, i.e. **"the purpose pipe"** (from RCA tools to reading tools) and **"the annotation pipe"** (from reading tools to RCA tools). This moves interoperability to the forefront. The ability of the artefact to work together with distinct platforms for exchanging data, requires embracing standards, intensive usage of APIs, and open architectures.

**MR5: GUI Seamlessness: GUIs of the coupled tools should be preserved as much as possible**
We should capitalise on whatever aspect the target audience is familiar with so that users can re-apply what they already know (transfer of learning). Basically, this involves sticking with the tools' GUI gestures. Existing mechanisms might be revised and repurposed, but the addition of new buttons or other kind of widgets should be avoided.

**MR6: Process Seamlessness: Interference with either the reading flow or the RCA should be minimized**
Coupling between annotation repositories and RCA tools should not be achieved at the cost of losing flexibility during either RCA or reading. The reading flow should not suffer as the result of the coupling. Likewise, new causes can arise during the RCA while others might need to be rephrased or re-arranged along the causal net as researchers delve into the literature. The coupling should not hinder this dynamicity.

So far, we have presented a nascent Design Theory whereby an artefact design that fulfils the aforementioned meta-requirements would have utility to reduce some of the causes of poor strategic reading, through providing coupling between annotation repositories and RCA tools. The next two sections describe the general features of a meta-design fleshing out this Design Theory, and an example instantiation: DScaffolding. DScaffolding is implemented as a Chrome plug-in that bridges MindMeister (as the RCA tool) and Mendeley (as the reference manager).

## 2.3 The Tools Coupled in DScaffolding

**The RCA Tool: MindMeister**
MindMeister is a web-based collaborative mind mapping application, which allows its users to visualise their thoughts in terms of mind maps [18]. A mind map is a diagram used to visually organise information. This can be pre-set in terms of a map template, i.e. a set of labelled nodes which can be later expanded by the user by adding new child

nodes. This provides a guide to gather information, especially interesting when this information is abundant and multi-sourced. This ductility together with the popularity mind maps enjoy, make mind mapping an interesting approach when it comes to explicate the problem, i.e. "to formulate the initial problem precisely, justify its importance, investigate its underlying causes, provide evidences and acknowledge related work" [19].

Figure 1 depicts the *ExplicateProblem* template at the onset. The template provides a head-start as for the information to be collected. Specifically, we resort to Coloured Cognitive Maps (CCM) [20]. The template supports the two types of CCM introduced in [20]:

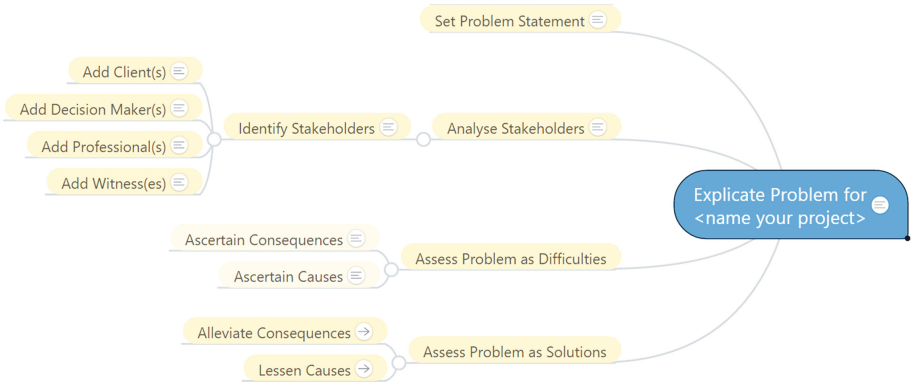


**Fig. 1.** Conducting RCA through MindMeister: the *ExplicateProblem* template.

- the "Problem as Difficulties" node, which focuses on the problem, what is undesirable about it (i.e. consequences), and what causes the problem and allows it to persist, and,
- the "Problem as Solutions" node, which focuses on the solution of the problem, what benefits would accrue from solving the problem or what causes of the problem might be reduced or eliminated to solve the problem.

Figure 2 instantiates the RCA template for the problem *"PhD students not bearing the RCA frame in mind when reading"*, i.e. our very problem!

**The Reading Tool: Mendeley**

Mendeley is an Elsevier-owned desktop and web program helping to manage and share research papers [21]. Papers can be arranged into folders, and tagged for easy retrieval. It includes a PDF viewer with sticky notes, text highlighting and full-screen reading. Quote annotation is achieved through highlighting where different colours are available.

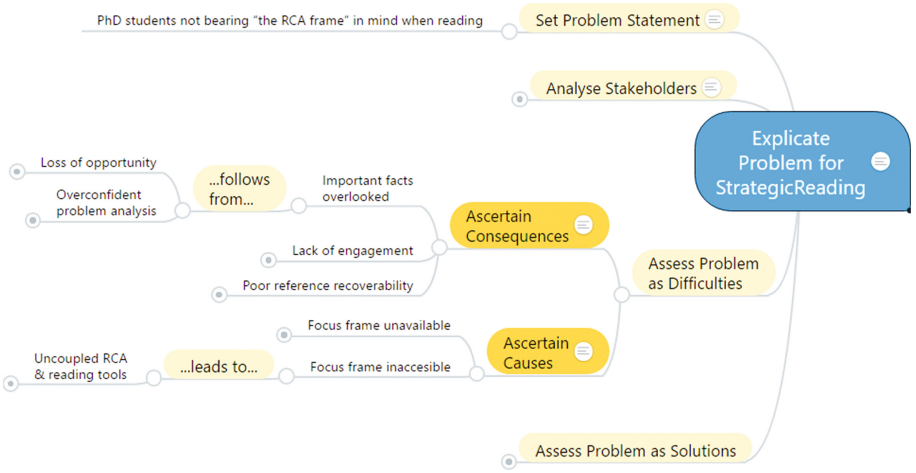


**Fig. 2.** RCA for our problem "PhD students not bearing the RCA frame in mind when reading".

## 3 Method

This research follows the DSR paradigm, in that it develops a new purposeful artefact to address a significant general problem – the lack of support for strategic reading in existing research tools. The work follows the five-step DSR Process Model of Vaishnavi and Kuechler [22, 23]: (1) Awareness of Problem, (2) Suggestion, (3) Development, (4) Evaluation, and (5) Conclusion. The next subsections describe each of these activities as conducted or planned during the research reported in this paper.

Awareness of Problem came from supervision of PhD students by the authors together with awareness of literature on recommended practices of strategic reading. Analysis of the problem identified causes of the problem as described earlier in this paper.

Suggestion came from awareness and availability of potential tools, interest by the first two co-authors in integrating different web-based tools, and researching the application programming interfaces (APIs) of available web-based tools. Suggestion was also drawn from understanding of different DSR methods and techniques what might be supported by a new artefact. The suggestion phase also involved development of functional requirements and non-functional requirements, as described above. Suggestion was also accomplished multiple times as different prototypes were tried out and new features were needed to make further improvements.

Development was undertaken in an iterative approach of prototyping different aspects of DScaffolding. Multiple versions were developed and reviewed and experimented with by the authors. Different versions of user interfaces were developed, tried out, and features deleted, modified, and added. Early versions focussed on integrating MindMeister and Mendeley. Prototypes were also evaluated by PhD students and DSR researchers at four different universities and formal and informal feedback gathered each time.

Evaluation thus far has been formative in nature. The research has undergone multiple cycles of suggestion, development, and formative evaluations. While version 1 of the purposeful artefact (the DScaffolding plug-in) has been released at the Chrome Web Store, DScaffolding is still under revision and we plan to make some more improvements (and also develop more documentation and learning materials) before conducting a formal evaluation of DScaffolding.

## 4 Artefact Description: Strategic Reading with DScaffolding

This section describes the features that make up the purposeful artefact developed to address the meta-requirements for a solution to the problem of "Strategic Reading in DSR". The outcome is a Chrome plug-in that realizes "the purpose pipe" and "the annotation pipe" for the specific case of MindMeister and Mendeley: DScaffolding. This plug-in is available at the Chrome's Web Store: https://chrome.google.com/webstore/detail/hkgmnnjalpmapogadekngkgbbgdjlnne.

Videos are provided for:

- Installation: https://youtu.be/hl6pnJGbVXY
- The Strategic Reading Process: https://youtu.be/jHP1MiqjVBM

Strategic reading is about targeted constructing of meaning by interacting with text [1]. By qualifying strategic reading as "RCA-driven", we stress that "the meaning" to be constructed is that of a (or should serve) RCA. This in turn requires a seamless integration between RCA tools and reading tools. The requirements with which this integration should comply were identified in Sect. 3, including three functional (MR1, MR2, MR3) and three non-functional (MR4, MR5, MR6) requirements. Table 1 highlights the functional requirements and the features within DScaffolding that realise those requirements.

**Table 1.** Features addressing functional meta-requirement in DScaffolding.

| Functional meta-requirements | DScaffolding features |
|---|---|
| *MR1: Identify RCA concerns* | *"Supporting Evidences?"* node |
| | *"Who else addresses it?"* node |
| *MR2: Annotate resources according to current RCA concerns (**the purpose pipe**)* | Concern cheat sheet |
| | Right mouse context menu for concerns |
| *MR3: Incorporate annotations as part of RCA (**the annotation pipe**)* | *"Annotation"* node |
| | Background colour & icons used to capture "the quality of the annotation" |
| | Tracking of annotation repositories |

This section elaborates on a Design Theory for this scenario. A Design Theory includes "a relationship between requirements and design that prescribes instantiating the design to achieve the requirements or simply indicates that there is utility to be had in instantiating the design for achieving the requirements" [20]. DScaffolding instantiates this theory for MindMeister and Mendeley. Next, we elaborate on DScaffolding's support for each functional requirement.

### 4.1 MR1: Provide Support for Setting Reading Purposes Based on RCA Issues

MindMeister supports RCA through mind mapping. MR1, i.e. identifying RCA issues, is then re-phrased as pinpointing those map nodes that will play the role of "reading purposes". In line with the non-functional requirements, this is realized as follows:

- GUI seamlessness. RCA nodes are turned into "Purpose nodes" through adding two possible children: the "Supporting Evidences?" node and the "Who else addresses it?" node. Introducing such nodes turns the father into a Purpose node. DScaffolding decorates Purpose nodes with one of up to eight different background colours (see Fig. 3).
- Process seamlessness. "Supporting Evidences?" and "Who else addresses it?" are created as any other node. However, DScaffolding constraints these nodes to hang from the appropriate fathers, i.e. cause/consequence nodes and means nodes, respectively (see Fig. 3).

The example in Fig. 3 shows three current RCA reading concerns: the problem statement (in green), "Poor reference recoverability" (in pink), and "Uncoupled RCA and reading tools" (in purple). Some evidence has already been collected for these concerns drawn from the literature. Note that the automatically generated background colours will later be mapped to Mendeley annotation background colours.

In accordance with the dynamic nature of RCA, researchers can alter which nodes play the role of "purpose" throughout the DS project. This is achieved by using the standard mechanism for node creation and deletion, i.e. by removing or adding "Supporting Evidences?" and "Who else addresses it?" nodes. No new interaction to be learnt by MindMeister users.

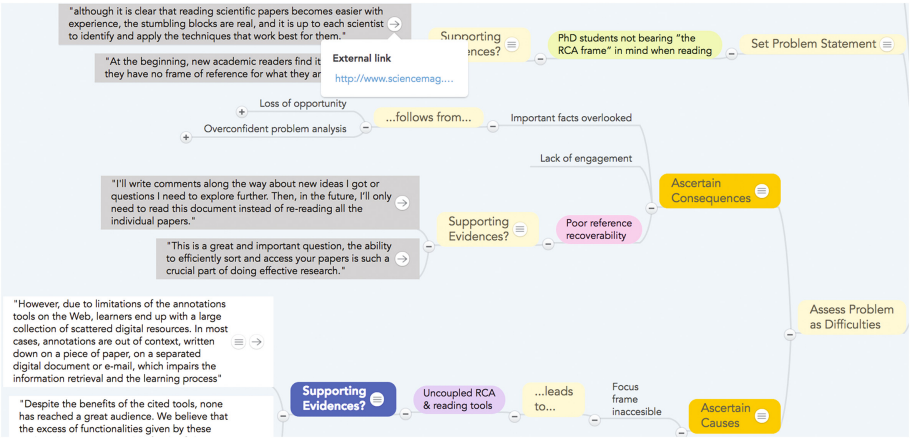


**Fig. 3.** DScaffolding RCA map with three purpose nodes. Available at https://www.mindmeister.com/830267652. (Color figure online)

### 4.2 MR2: Provide Support for Annotating Literature Resources as Relevant to RCA Issues ("the Purpose Pipe")

Annotating is the act of creating associations between a reading resource (e.g. a PDF document or a Web page) and metadata in terms of a comment, ranking stars, or a highlight that qualifies the resource. Here, we are constrained to the annotating mechanism provided by the reading platform, specifically, those for annotating excerpt rather than the whole resource. For Mendeley, this is restricted to highlighting since tags are used to characterize the whole resource.

No matter the approach, the important point is that now annotating is not conducted in a vacuum, but framed by the current concerns within RCA. RCA issues provide researchers with the questions to be answered when reading. Annotation mechanisms (tags & highlighting colours) now convey RCA meaning. DScaffolding captures these issues through Purpose nodes. As discussed earlier, Purpose nodes are those that have "Supporting Evidences?" and "Who else addresses it?" as a child. Purpose nodes hold a label and a background colour. Labels become tags while background colours equate to those used for highlighting in Mendeley. This sets the mapping between RCA concerns (in MindMeister) and annotations (in Mendeley). But this is not enough.

Even if a mapping is set, it is very unlikely that researchers will remember it (i.e. what colour matches which purpose). We need to make Mendeley "purpose-aware". However, annotation mechanisms (e.g. highlighting) are wired-in, only accessible to tool owners. Hence, we have to resort to external means: a cheat sheet to be placed by the Mendeley desktop (see Fig. 4).

Mendeley provides eight different colours for annotation highlighting. Yellow is left for "structural" highlighting (i.e. attributing different levels of importance). The remaining seven are mapped to RCA issues' background colours. A cheat sheet about what these colours stand for can be obtained from MindMeister. Researchers can then place this cheat sheet by their Mendeley desktop application (see Fig. 4).

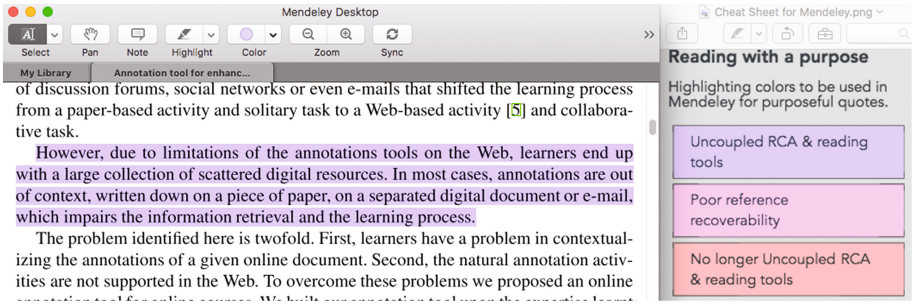


**Fig. 4.** Cheat sheet used for RCA awareness in Mendeley (left side). The CheatSheet is obtained as a screenshot from MindMeister. In the screenshot, the velvet highlight colour corresponds to the "RCA & reading tool coupling" issue whose rationales should be found in the RCA. (Color figure online)

### 4.3 MR3: Provide Support for Framing and Incorporating Annotations as Part of RCA ("the Annotation Pipe")

In our vision, annotations do not exist in a vacuum, but are contextualised by RCA. DScaffolding fleshes this out by naming Mendeley folders and MindMeister maps alike. Once this link is set, DScaffolding tracks annotations made in resources held in these folders, to later enrich the namesake MindMeister map. In so doing, DScaffolding realizes the annotation pipe. But what is meant by "enrich"? Enrich refers to DScaffolding automatically creating Annotation nodes out of annotations coming from Mendeley repositories.

An Annotation node addresses an RCA issue, and as such, it hangs from the corresponding RCA node (see Fig. 3). Node properties include: a label, an attached comment and a background colour. For Annotation nodes:

- the label holds the text being highlighted in the annotated resource,
- the comment keeps a link to the resource URL (if available). Researchers can click on the link icon to move straight to the manuscript in Mendeley,
- the background colour reflects the nature of the source: "white" for annotations coming from journals and conferences, and "grey" if coming from the grey literature (not discussed here).

In addition, annotations inherit the reputation of their sources. Annotations coming for reputable sources add a "star" icon to their labels. So far, the reputation is set by users. For instance, Mendeley allows users to tick a "star" to mark sources as favourites. Although "favourite" is quite an elusive notion (no clear rationale for ticking this off), DScaffolding interprets the star as a sign of the source's reputation and soundness. This reputation travels together with the reference.

### 4.4 Features Implementing the Non-functional Meta-Requirements

This section addresses the impact on interoperability (MR4), and whether the interaction narrative of MindMeister/Mendeley has been affected by the introduction of the means for strategic reading (MR5 & MR6).

**MR4 – Interoperability**
DScaffolding uses intensively APIs, and attempts to adhere to W3C standards for annotation description. Architecture wise, we follow the "Tool Integration via Process Flows" pattern [24]. This facilitates bringing in new "reading tools" by developing the appropriate components.

**MR5 – GUI seamlessness**
To what extent have existing GUIs being altered by the introduction of DScaffolding? Answers follow:

- MindMeister. Its GUI is being extended with a "CheatSheet" button that permits to obtain a screenshot of the current "reading purposes".
- Mendeley. No change in its GUI.

**MR6 – Process seamlessness**
To what extent have traditional practices being altered by the introduction of DScaffolding? Answers follow:

- practice: node creation. We stick to MindMeister practices. For traditional MindMeister users, the only difference stems from some nodes (e.g. Annotation nodes) being automatically generated. Once created, Annotation nodes are handle as any other node: they can be reshaped or moving around at users' wish
- practice: annotation. Mendeley users need now to look at the CheatSheet to select the appropriate background highlighting colour (see Fig. 4).

## 5 Evaluation

Evaluation followed a naturalistic approach: 5 PhD students were free to use DScaffolding for three months, and next enquired about their experience. This sample size is certainly not enough, but might be sufficient for understanding initial reactions. Figure 5 displays the questionnaire along the results. Next, results are commented along the two aims of the evaluation: assessing usability and effectiveness.

Usability has to do with seamlessly integrating DScaffolding with existing processes (MR5 & MR6) so that the existing flows are minimally disturbed. Questions 1 and 2 check the eventual disturbance brought about by DScaffolding. For MindMeister, this involves the need to create "Supporting nodes?". For Mendeley, this involves the use of a CheatSheet. Except subject S2, DScaffolding did not seem to involve a main disruption from previous habits. Specifically, the requirement of having the CheatSheet by the Mendeley desktop does not seem to imply a main hassle.

Effectiveness has to do with RCA issues serving as appropriate focal points during reading (question 3). As a by-product, we also assessed the interest of including annotations as part of RCA diagrams (question 4, 5 & 6). Questions 7 and 8 provide a general sentiment about the tool. In general, subjects were "mild" about the effectiveness of DScaffolding to keep them focus. However, an unexpected outcome was the help that indexing annotations along RCA concerns brings to reference recoverability (the highest ranked assertion). This seems to suggest that using RCA issues for strategic reading, might not only facilitate focus but also help root-cause analysis. The question is whether this impact on RCA can be regarded as an evidence of strategic reading?

If we go back to the definition of strategic reading, i.e. conceiving reading as a process of constructing meaning by interacting with text [1], the notion of "constructing meaning" can certainly be equated to developing the RCA map. By framing Mendeley annotations into the RCA map, researchers are seamlessly "constructing meaning": making sense of their cause analysis.

One main thread to validity is that of subjects belonging to the same research group that the DScaffolding authors. Though this risk was explicitly warned about, existing relationships could have biased the outcome.

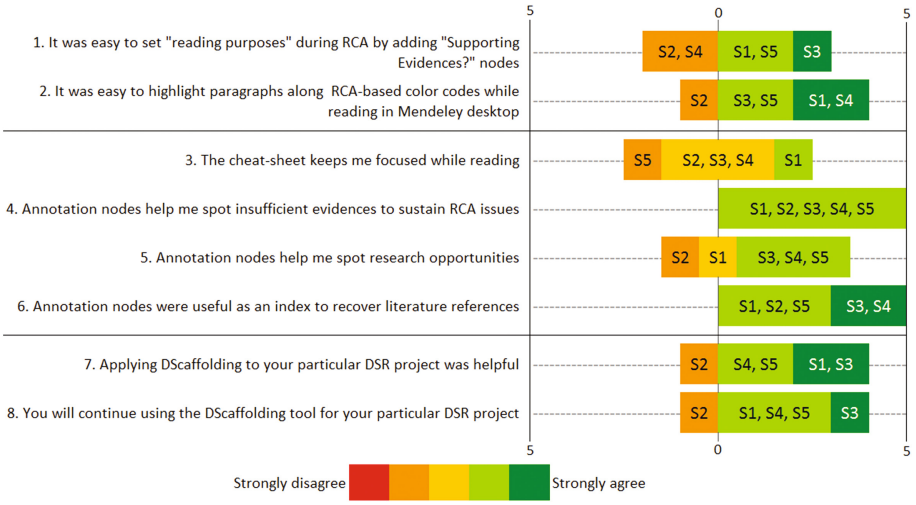


**Fig. 5.** Diverging stacked bar chart for the satisfaction questionnaire using likert scales. The "5" on the left means the five subjects, i.e. S1, S2, etc., *Strongly Disagree,* while "5" on the right corresponds to all *Strongly Agree*. Gradients in colour indicate the strength of their (dis) agreement. (Color figure online)

## 6 Conclusions

Strategic reading is a main skill for researchers. Our Design Theory is that RCA may provide main drivers of attention when reading. The theory states that this can be achieved by sustaining both "RCA awareness" while reading (i.e. the purpose pipe that channels RCA issues to reading platforms) and "literature awareness" while conducting RCA (i.e. the annotation pipe that channels literature evidences towards RCA platforms). DScaffolding is used to assess the extent to which this theory holds. First evaluations indicate that not only reading but also RCA might benefit from a tight coupling between these two processes.

The insights for this theory can be of interest to:

- RCA tool developers, as for the importance of evidence gathering within the tool itself to spot analysis weaknesses and improving reference recoverability,
- reading tool developers, as for the use of RCA issues to anchor focus, and hence, enabling strategic reading,
- the DSR community, as for stressing even further the importance of RCA, now as a strategic reading enabler.

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