Development of a Design Science Artefact to Teach Computing Students: A Systematic Literature Review

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Abstract: Teaching students to conduct a rigorous systematic literature review (SLR) may be challenging, given the growing output of scientific literature and the increasing plethora of supporting software and artificial intelligence tools such as ChatGPT. A SLR supported by design science artefacts and emerging artificial intelligence tools have the potential to overcome the challenges posed by increasing scientific literature. However, guidelines and steps required to conduct a SLR still need to be clarified in the existing literature. Furthermore, existing design science artefacts and software tools do not support teaching students to conduct rigorous systematic reviews. This paper presents guidelines on the required steps for a rigorous SLR and proposes a Researchbuddie artefact to support teaching SLR. Using a systematic review and design science findings, identify SLRs four main phases of planning, conducting, evaluating and reporting reviews, each supported by itemised sub-steps. Furthermore, a design science artefact Researchbuddie is proposed to support teaching SLR. Therefore, the paper contributes to guidelines for teaching SLR for Information Systems students with phases, sub-steps and a proposed Researchbuddie artefact.

Keywords: Systematic literature review, design science research, information systems, artefact, teaching SLR

1. Introduction

Teaching postgraduate students to conduct rigorous systematic literature reviews (SLRs) may be challenging, even more so given the growing output of scientific literature (Denzler et al, 2021) and the ever-increasing plethora of software and artificial intelligence tools such as ChatGPT. According to Kitchenham and Charters (2007), the original impetus for Systematic literature review (SLR) was to support evidence-based medicine, and many guidelines reflect this viewpoint. The SLR that emerged as an evidence-based medical movement has spread to social science research (Boell & Cecez-Kecmanovic, 2015). Additionally, the popularity of SLRs in various fields challenges the need for discipline-specific methods, especially for Information Systems (IS) students. The broad nature of IS research suggests varied approaches to research and research subject matter. Rigorous systematic literature searches are often complex, error-prone and time-consuming, requiring adequate technological assistance (Sturm & Sunyaev, 2019).

There is a growing consensus that reviewing literature can be an overwhelming task (Bandara et al, 2015), time-consuming and error-prone (Marshall & Brereton, 2013), with Jennex (2015), an editor-in-chief in one of the top Information journals alluding to the declining quality of literature reviews in papers submitted. Consequently, Stefanovic et al (2021) indicate that, in recent years, software tools and artefacts have been designed to enhance the efficiency, accuracy, and ease of the literature review process by reducing time, increasing the quality of assessment, minimising researcher subjectivity, and simplifying the review. However, software tools and artefacts to aid in the SLR process have yet to be discussed in a consolidated way (Bandara et al, 2015). Moreover, in contrast to Bai et al (2019), we found that there needs to be more homogeneity regarding the number of steps used in the exemplary literature on guidelines for conducting SLRs in IS research. Furthermore, in some of the papers, the sequence of the steps may need to be clarified. For example, Okoli (2015) applied practical screening before the literature search, and Marshall and Brereton (2013) placed protocol development before identifying the research. Previous studies that have examined the use of tools to support SLRs include Marshall and Brereton (2013), who identify and classify tools that can help to automate parts or all of the SLR process, and Stefanovic et al (2021) evaluated three tools to support a SLR using the DESMET methodology. Moreover, Sundaram and Berleant (2023) identified the objectives of the SLR automation studies and aspects of systematic literature steps that were automated. However, these studies do not explore the potential of the artefacts and tools in supporting the teaching of SLR nor do provide a detailed discussion of the steps, including the tasks to be completed at each step. In the SLR, design science may support conducting a rigorous SLR as design artefacts may generate knowledge of how things can and should be constructed or arranged by using creative and innovative solutions to problems, building on existing parts of a solution, combining revisions, and extending actual design knowledge (vom Brocke et al, 2020). Moreover, artefacts are used when designing, developing, implementing, maintaining, and using IS and software systems (Wieringa, 2014). To address the gap relating to artefacts to teach SLR, the main research question is: What design science research artefacts and tools support teaching various steps in a SLR in IS research? The following sub-research-questions support the main research question:

1. What are the SLR steps used in IS research?
2. What SLR tools and artefacts support each SLR step conducted in IS research?
3. How can design science research artefacts adapt existing tools to support teaching SLR to postgraduate students?

In answering the research questions, the paper builds on the research of scholars such as Benke et al (2020), Berkemeier et al (2019), Goeken and Patas (2010), Niemoller et al (2019), Simmert et al (2019), Stefanovic et al (2021), and Sturm and Sunyaez (2019), who have applied design science research to develop solutions to real-world problems. In addition, the paper draws from prior work on guidelines to conduct SLRs, such as Okoli (2015) and Bai et al (2019).

2. Methodology

There are several methodologies that one may adopt in the design of design science artefacts. According to Siemon et al (2022), various methods, including systematic reviews, interviews, and experiments, may be used in design science research to ensure that design science knowledge is comprehensible. In this paper, we sequentially adopted a SLR and design science. The AIS library was identified as a viable source as the platform where Senior Scholars Information Systems publish. Using search phrases that included "SLR", and "tools," and "SLR", and "design science," the search was conducted. The search was further filtered for journal articles, which were extracted based on the filter. The initial search generated 2 775 results, and filtering for journal articles resulted in 221 results, resulting in a dataset of 11 papers selected for analysis. These were augmented to 16 articles and one technical report from snowballing for highly influential papers from those identified in the initial data depicted in Table 1.

In analysing the selected articles, an inductive approach was adopted, and the SLR search for artefacts and tools was augmented with a search of five tools assessed for potential to support the various SLR steps. The assessment is attached as Appendix 1. In the second phase, the SLR and assessment results informed the design of science research to develop the Researchbuddie artefact. March and Storey (2008) suggest that design science research contribution requires the identification, description, and solution of a relevant organisational IT problem, supported by the development of a novel IT artefact. Furthermore, Hevner et al (2004) indicate that design science intends to create and evaluate IT artefacts to solve identified organisational problems.

Table 1: Primary papers

#	Year of publication	Authors	Articles	Journals	Google Scholar citations
1	2022	Sundaram, G. and Berleant, D.	Automating SLRs with natural language processing and text mining a SLR	Eighth Int. Congress on Information and Communication Technology	0
2	2021	Stefanovic, D., Havzi, S., Nikolic, D., Dakic, D., & Lolic, T.	Analysis of the tools to support SLR in software engineering	IOP Conference Series: Materials Science and Engineering	4
3	2020	Benke, I., Feine, J., Venable, J. R., & Maedche, A.	On implementing ethical principles in design science research	AIS Transactions on Human - Computer Interaction	11
4	2019	Bai, Z., Jain, N., Kurdyukov, R., Walton, J., Wang, Y., Bentley Wasson, T. and Zhu, X.	Conducting SLRs in Information Systems: An Analysis of Guidelines	Issues in Information Systems	9
5	2019	Berkemeier, L., Zobel, B., Werning, S., Ickerott, I. and Thomas, O.	Engineering of augmented reality-based information systems design and implementation for intralogistics services	Business & Information Systems Engineering	62
6	2019	Niemoller, C., Metzger, D., Berkemeier, L. and Zobel, B.	Mobile service support based on smart glasses	Journal of Information Technology Theory and Application	8

#	Year of publication	Authors	Articles	Journals	Google Scholar citations
7	2019	Simmert, B., Ebel, P.A., Peters, C. and Bittner, E.A.C.	Conquering the challenge of continuous business model improvement	Business & Information Systems Engineering	24
8	2019	Simonofski, A., Serral Asensio, E. and De Smedt, J.	Hearing the voice of citizens in smart city design: the CitiVoice framework	Business & Information Systems Engineering	70
9	2019	Sturm, B. and Sunyaev, A.	Design principles for systematic search systems: a holistic synthesis of a rigorous multi-cycle design science research journey	Business & Information Systems Engineering	38
10	2019	Morana, S., Kroenung, J., Maedche, A. and Schacht, S.	Designing process guidance systems	Journal of the Association for Information Systems,	20
11	2015	Okoli, C.	A guide to conducting a standalone SLR	Communications of the Association for information Systems	963
12	2015	Boell, S. K., & Cecez-Kecmanovic, D	On being 'systematic' in literature reviews in IS	Journal of Information Technology	566
13	2015	Bandara, W., Furtmueller, E., Gorbacheva, E., Miskon, S. and Beekhuyzen, J.	Achieving rigor in literature reviews: Insights from qualitative data analysis and tools-support	Communications of the Association for information Systems	337
14	2014	Fink, A.	Conducting a SLR from internet to paper	Book	4576
15	2013	Marshall C. and Brereton, P.	Tools to support SLRs in software engineering: A mapping study	ACM / IEEE International Symposium on Empirical Software Engineering and Measurement	118
16	2010	Goeken, M. and Patas, J.	Evidence-based structuring and evaluation of empirical research in requirements engineering fundamentals, framework, research map	Business & Information Systems Engineering	23

3. Findings and discussion

A meta-analysis revealed 13 main steps spread across the various papers, and the most homogeneous step was the selection of studies, followed by the database search step and the search string development step. The steps that had the highest level of heterogeneity and appeared in fewer papers were evaluating the review protocol, specifying the dissemination mechanism and evaluating the SLR report. Despite the evaluation protocol's heterogeneity, it is a critical step in supporting teaching SLR as it could support individual student checks, peer reviews and assessments by the educator. The meta-analysis results are depicted in Figure 1.

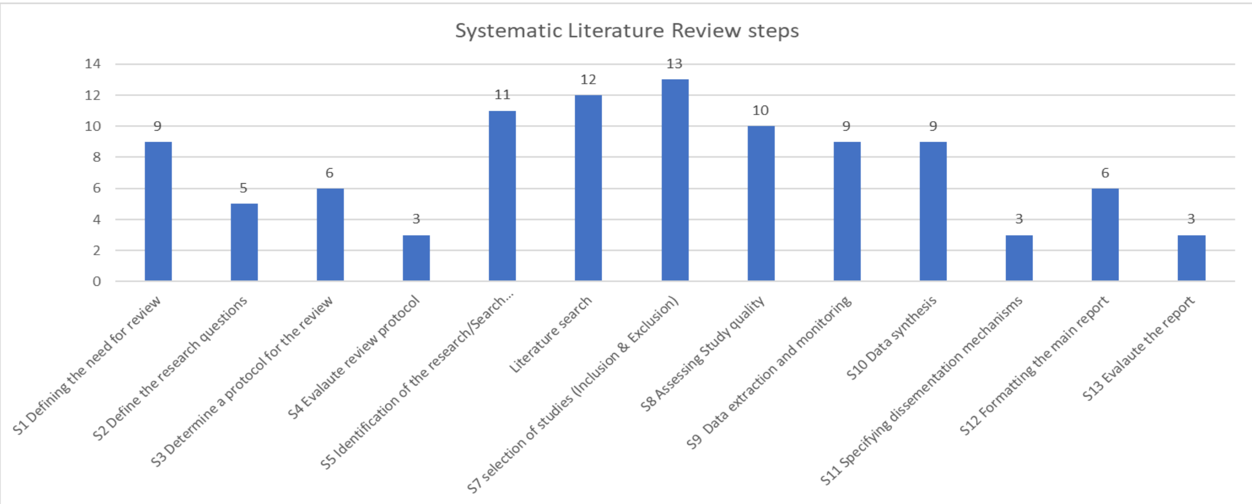

Figure 1: Meta-Analysis SLR steps

The meta-analysis was followed by a descriptive analysis, guided by Kitchenham and Charters (2007), to gain deeper insights into the steps to provide depth of tasks in each step. Therefore, potential guidelines to facilitate teaching and learning in a SLR were developed. Based on the findings, SLR steps allude to 13 steps that may be categorised into four phases: planning, conducting, reporting (Kitchenham & Charters, 2007) and evaluating the SLR. These four phases are illustrated in Figure 2 and discussed in the subsequent sections.

Figure 2: SLR phases

3.1 Planning phase

The planning phase of the SLR process involves four main steps: defining the need for review, formulating a research question, and establishing and evaluating the review protocol. Defining the need for review, also referred as problem definition, involves identifying the purpose and goals of the review and ensuring clarity for readers (Bai et al, 2019; Benke et al, Kitchenham & Charters, 2007; Marshall & Brereton, 2013; Morana et al, 2019; Okoli, 2015; Stefanovic et al, 2021; Sundaram & Berleant, 2023). Furthermore, Kitchenham and Charters (2007) indicate that the need for a systematic review arises from the requirement to summarise all existing information about some phenomenon thoroughly and unbiasedly or as a prelude to further research activities and includes evaluating existing reviews against set criteria. Following the identification step, research questions are formulated (Fink, 2014; Goeken & Patas, 2010; Kitchenham & Charters, 2007; Sundaram & Berleant, 2023) with a question precisely stated to guide the review (Fink, 2014). According to Kitchenham and Charters (2007), individual population intervention, comparison, and outcome (PICO) facets can help refine the research question.

The research question definition precedes the protocol determination, development or establishment step (Bai et al, 2019; Fink, 2014; Kitchenham & Charters, 2007; Marshall & Brereton, 2013; Okoli, 2015; Stefanovic et al, 2021; Sundaram & Berleant, 2023). The protocol outlines how each step in the SLR will be executed, including tasks in the planning phase (Kitchenham & Charters, 2007). Furthermore, Okoli (2015) highlights the importance of a protocol, especially in reviews involving multiple reviewers, to ensure consistency in the review process. After developing the protocol, the next step is protocol evaluation or validation (Kitchenham & Charters, 2007; Stefanovic et al, 2021; Sundaram & Berleant, 2023). Furthermore, Kitchenham and Charters (2007) indicate that evaluating the protocol is crucial and should involve study supervisors to enable the assessment of critical aspects such as search strings being appropriately derived from research questions, the potential of the data to be extracted to address research questions adequately and ensuring the data analysis procedures' appropriateness to answer the research question.

3.2 Conducting phase

Conducting the review phase is the most engaging part of the process and consists of six steps: search string development, literature search, study selection, assessment of study quality, data extraction, and synthesis. The initial step in conducting the review is one of the homogeneous steps in most papers; others refer to it as choosing, defining, developing, and generating search strings (Benke et al, 2020; Fink, 2014; Goeken & Patas, 2010; Niemoller et al, 2019; Simonofski et al, 2019; Sundaram & Berleant, 2023) or keyword identification, search query creation (Morana et al, 2017) and search strategy (Kitchenham & Charters, 2007). Search string development involves using the research question to identify keywords and create search queries or strings (Goeken & Patas, 2010). Moreover, in formulating search strings, the keyword synonyms are often used (Benke et al, 2020), along with Boolean operators such as 'AND' and 'OR'.

The literature search step is referred to define, identify, establish, and determine databases (Benke et al, 2020; Fink, 2014; Goeken & Patas, 2010; Morana et al, 2017; Simmert et al, 2019; Sturm & Sunyaev, 2019). It is also called search database (Berkemeier et al, 2019), search literature (Bai et al, 2019; Kitchenham & Charters, 2007; Okoli, 2015) or extract literature (Bandara et al, 2015). It entails defining the databases to be searched and extracting articles from the identified sources (Goeken & Patas, 2010), explicitly describing the details of the literature search and justifying the comprehensiveness of the search (Okoli, 2015). In the field of IS, popular databases for searches include EBSCOhost, AIS Electronic Library (Morana et al, 2017; Niemoller et al, 2019), ScienceDirect, ISI Web of Knowledge, Springerlink, Emerald, Wiley Online Library (Niemoller et al, 2019) and ProQuest, ACM Digital Library and IEEE Xplore Digital Library (Morana et al, 2017), and backwards and forward searches, also known as snowballing, may be used to supplement the database search by including highly influential articles extracted from the databases to ensure comprehensiveness (Morana et al, 2017; Simonofski et al, 2019).

The selection of studies is referred to as practical screening or preselection (Bai et al, 2019; Goeken & Patas, 2010; Kitchenham & Charters, 2007; Okoli, 2015; Stefanovic et al, 2021; Sundaram & Berleant, 2023). The study selection step involves applying practical screening criteria to the articles obtained from the preliminary literature search with the aim to identify relevant articles while excluding irrelevant ones (Fink, 2014). If multiple search strings are used, the screening is applied to identify articles that meet the criteria of both search strings (Benke et al, 2020). Inclusion and exclusion criteria used in study selection should be based on the research question and piloted to ensure studies are correctly classified (Kitchenham & Charters, 2007) with factors such as language (Fink, 2014), article type, journal, authors, setting, participants/subjects, research design, sampling method, and publication date considered (Kitchenham & Charters, 2007). Furthermore, Morana (2017) adds that peer review is also considered in study selection. Furthermore, the inclusion and exclusion criteria need to be justified, articulating how the resulting review may still be comprehensive given the practical exclusion criteria (Okoli, 2015).

Selected studies must be assessed and appraised for quality, the step is also named selection review (Bai et al, 2019; Bandara et al, 2015 ; Fink, 2014; Goeken & Patas, 2010; Kitchenham & Charters, 2007; Marshall & Brereton, 2013; Okoli 2015, Stefanovic et al, 2021; Sundaram & Berleant, 2023). The quality assessment step explicitly defines the criteria to judge the papers based on methodological quality (Okoli, 2015). For quantitative research, considerations include study design, conduct, analysis, and conclusions, while qualitative research criteria include the credibility of findings, knowledge extension, sample definition, and case selection (Kitchenham & Charters, 2007). In addition, different classification systems can be used to evaluate the studies, such as meta-analysis, narrative reviews, qualitative and quantitative cross-sectional work, case studies, experiments, and expert interviews (Goeken & Patas, 2010).

The data extraction and monitoring step involves systematically extracting bibliometric and descriptive content from each study based on a defined strategy (Bai et al, 2019; Benke et al, 2020; Fink, 2014; Marshall & Brereton, 2013; Morana et al, 2017; Okoli, 2015; Stefanovic et al, 2021; Sundaram & Berleant, 2023). Furthermore, to assure reliability, validity and accuracy, a standardised form is used to record the information accurately; reviewers are trained, the quality of the review is monitored, and the extraction is pilot-tested (Fink, 2014). Moreover, Kitchenham and Charters (2007) suggest that data extraction should be supported with separate forms to accurately record information from primary studies for review questions and study quality criteria. Data synthesis is the last step in conducting the review phase (Bai et al, 2019; Bandara et al, 2015; Fink, 2014; Kitchenham & Charters, 2007; Okoli, 2015; Stefanovic et al, 2021; Sundaram & Berleant, 2023).

Also called data analysis, data synthesis combines the extracted facts using appropriate techniques, such as quantitative, qualitative, or both (Okoli, 2015). The data synthesis step includes coding, analysing, and summarising evidence from the extracted data (Bai et al, 2019). According to Bandara et al (2015), data synthesis may be divided into organising and preparing for analysis, establishing a pre-coding scheme and coding guidelines, and then conducting the analysis. Different types of synthesis, such as meta-analysis and descriptive analysis, may be used. Meta-analysis may be used to combine results using statistical methods (Fink, 2014) and to reflect the influence of heterogeneity sources on study type, quality, and sample size through tabulation (Kitchenham & Charters, 2007). In contrast, the descriptive analysis provides interpretations based on the reviewers' expertise and the available literature (Fink, 2014) and may integrate natural language results and conclusions through reciprocal translation, using refutational analysis when studies contradict each other, and line argument analysis to identify critical issues in a set of studies (Kitchenham & Charters, 2007).

3.3 Reporting phase

The reporting phase provides a detailed write-up of the results review (Stefanovic et al, 2021). The reporting phase comprises two steps specifying the dissemination mechanism or strategy and formatting the main report (Kitchenham & Charters, 2007; Sundaram & Berleant, 2023). Specifying dissemination mechanism (Sundaram & Berleant, 2023) also referred to dissemination strategy (Kitchenham & Charters, 2007). According to Kichenham and Charters (2007), dissemination strategy entails planning how results will be distributed, especially for non-academic platforms. Formatting the main report step is informed by the medium in which the review report will be disseminated; for instance, if a journal is targeted, formatting guidelines of the chosen journal will be followed (Kitchenham & Charters, 2007). Of the reviewed papers, it was discovered that the formatting step was only reiterated by Sundaram and Beleant (2023). However, their article does not acknowledge how the step was conducted; this highlights the saliency of specific steps whereby authors perform them without recording them. The saliency was noted in most primary papers using the reporting phase as the last step. Only Bai et al (2019) Bandara et al (2015), Marshall and Brereton (2013), Sundaram and Berleant (2023) and Okoli (2015) have mentioned the reporting process.

3.4 Evaluation phase

Evaluating the report (Kitchenham & Charters, 2007; Sundaram & Berleant, 2023), also called validating the report (Stefanovic et al, 2021), is the last step. Evaluation entails a peer-review process, expert reviews and independent evaluators (Kitchenham & Charters, 2007). Other evaluation tools include the meta-analysis of observational studies in epidemiology (MOOSE) checklist and PRISMA, which originated from the health sciences (Page et al, 2021; Stroup et al, 2000) and evaluation criteria for reviewers stemming from management sciences (Kuckertz & Block, 2021). The categories within the evaluation tools include an introduction (Kuckertz & Block, 2021; Page et al, 2021), background (Stroup et al, 2000), research questions, search strategy, reporting of methods (Kuckertz & Block, 2021; Page et al, 2021; Stroup et al, 2000), result, conclusion and future research (Kuckertz & Block, 2021; Page et al, 2021). The checklist categories are homogeneous. However, there is heterogeneity in the title and abstract, appearing in PRISMA only. The evaluation phase may be necessary to teach SLR, as evaluation is a critical element of the pedagogy. Furthermore, the evaluation phase could include internal and external mechanisms (Kitchenham & Charters, 2007). Based on the SLR results and assessment of existing design science software tools and artefacts, the artefact for teaching SLR was conceptualised.

4. Design science artefact for teaching SLR

In the conceptualisation of the artefact for teaching SLR, Gregor and Jones (2007) specify that any design theory should include as a minimum, purpose and scope, constructs, principles of form and function, artefact mutability, testable propositions, and justificatory knowledge. The purpose of the Researchbuddie artefact is to provide a structured framework and guidance to conduct SLRs in IS as illustrated in are illustrated in Figure 3. The Researchbuddie artefact incorporates essential constructs such as the identified SLR steps at each of the four phases. The artefact follows principles of form and function to ensure usability, including intuitive interfaces, step-by-step guidance, and flexibility for customisation with the steps itemised on the user interface. Its mutability allows users to adapt it to tasks required for each step. Finally, the design includes testable propositions to evaluate the artefact's effectiveness and justificatory knowledge from existing literature review methodologies.

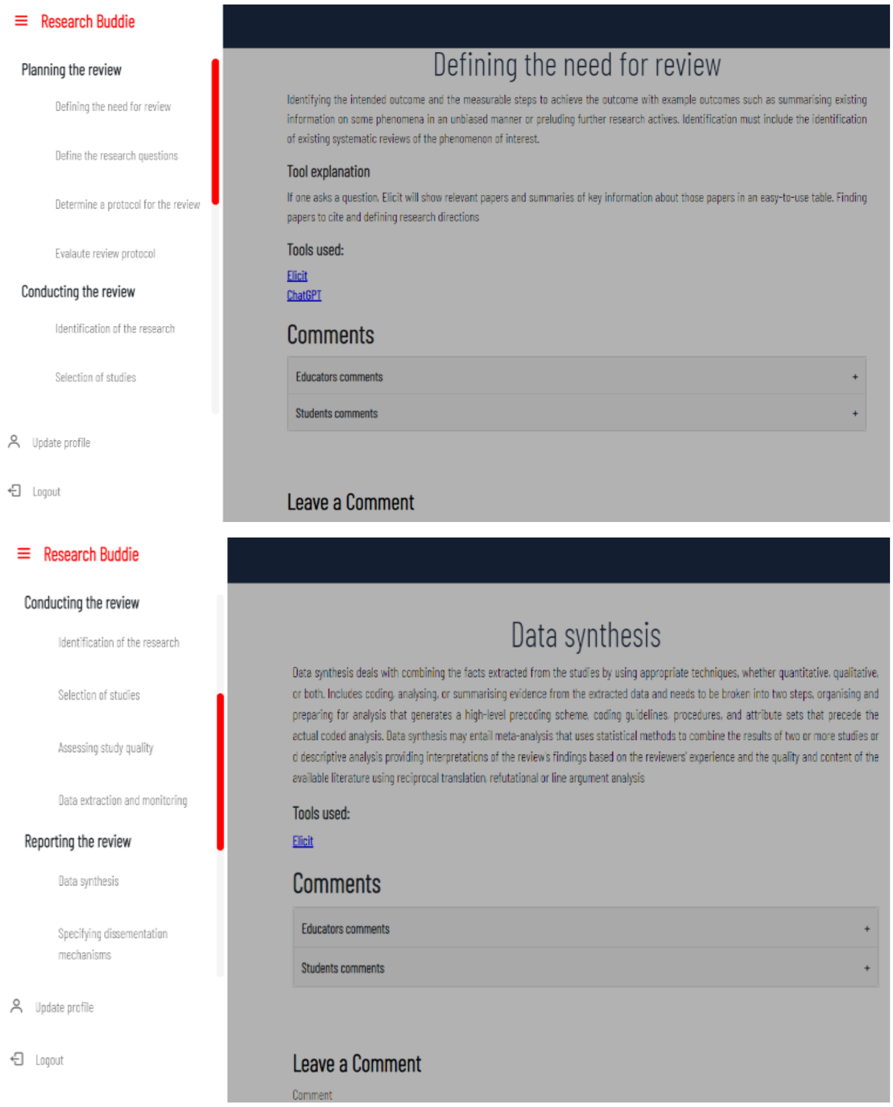

Figure3: Researchbuddie screenshots

5. Conclusions, limitations and future research

This paper examined design science research artefacts and tools that support teaching various steps in a SLR in IS research. Based on a SLR, the primary phase and sub-steps were identified, and guidelines for completing each step's tasks were explained in detail. The identified phases and steps were used as a basis to conceptualise a novel Researchbuddie artefact that may be used to support educators in facilitating a SLR. The designed Researchbuddie artefact may support teaching SLRs, integrating emerging artificial intelligence tools such as ChatGPT, Elicit AI and perplexity to overcome the challenges posed by increasing scientific literature and delivering rigorous SLRs. In addition, the paper may spark debates on the ethical usage of artificial intelligence tools and presents an opportunity for educators and students to share experiences on using artificial intelligence in conducting effective SLRs. However, the study has some limitations. It only focused on the AIS library journal articles. A fundamental limitation is that the proposed Researchbuddie artefact is still to be implemented and evaluated in real-world settings to assess its effectiveness and user acceptance. Future work will focus on implementation and validation with focus group interviews that will include information systems experts with in-depth experience conducting SLRs.

Additionally, the review has uncovered some opportunities for future research that include examining the impact of artificial intelligence tools on digital inequality in student research, as some of the tools bring cost implications. Furthermore, the guidelines for the ethical use of artificial intelligence tools to support a high-quality SLR are required.

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Appendix

Appendix 1: Reviewed Artificial intelligence research tools

	Elicit	Lit maps	Research Rabbit	ChatGPT	Consensus
S1 Defining the need for review	□□ □□□	X	X	□□□ □□	X
S2 Define the research questions	□□□ □□	X	X	□□□ □□	X
S3 Determine a protocol for the review	X	X	X	□□ □□□	X
S4 Evaluate review protocol	X	X	X	□□□□ □	X
S5 Identification of the research/Search string Development	□□□ □□	X	X	□□ □□□	X
Literature search	□□□	X	□□ □□□	□□ □□□	□□ □□
S7 Selection of studies (Inclusion & Exclusion)	□□□ □□	□□□ □□	X	□ □□□□	X
S8 Assessing Study Quality	□□□ □□	X	X	□□□□ □	X
S9 Data extraction and monitoring	□□□ □□	X	X	□□□ □□	□□ □
S10 Data synthesis	X	X	X	□□ □□□	□□□□ □
S11 Specifying dissemination mechanisms	X	X	X	□□□ □□	X
S12 Formatting the main report	X	X	X	□□□□ □	X
S13 Evaluate the report	X	X	X	□□□□ □	X