

Institution: Keele University		
Unit of Assessment: UoA11 Computer Science and Informatics		
Title of case study: Improving Systematic Reviews with the Systematic Review Toolbox (SRToolbox)		
Period when the underpinning research was undertaken: 2004-2018		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Professor Barbara Kitchenham	Professor (currently Emeritus Professor)	1988 - 2019
Professor Pearl Brereton	Professor (currently Emeritus Professor)	1982 - 2019
Period when the claimed impact occurred: 2014-present		
Is this case study continued from a case study submitted in 2014? N		
1. Summary of the impact (indicative maximum 100 words)		
<p>Kitchenham and Brereton pioneered evidence-based software engineering (EBSE), and the use of systematic reviews (SRs) in software engineering. In 2015, the Keele group launched the first community-driven comprehensive catalogue of evaluated automated tools, the SRToolbox.</p> <p>SRToolbox builds on 25 years' of EBSE research, which includes development of SR protocols and an evaluative framework for SR tools. By linking 140 evaluated tools, SRToolbox enables fast, accurate and efficient SR, and is used in SR reviews in many domains, including informing policy in clinical, government and non-governmental (NGO) settings.</p> <p>SRToolbox has established a SR community that supports developing SR practice and tool development.</p>		
2. Underpinning research (indicative maximum 500 words)		
<p>Keele Professors Kitchenham and Brereton led the discipline of EBSE for three decades, developing professional and systematic approaches in software engineering and research. The foundations of SRToolbox are in the research reported in a seminal paper on evidence-based practices for software engineering (3.2) at the 2004 International Conference on Software Engineering (ICSE), for which Kitchenham was awarded an <i>ACM SigSoft 10-year Impact Award</i> in 2014. SR has emerged as one of the most widely-used methods of EBSE (3.2).</p> <p>SR is "a means of evaluating and interpreting all available research relevant to a particular research question, topic area or phenomenon of interest" (3.1). In researching and using SR, Kitchenham, Brereton and their collaborators have published over 100 papers. The initial research adapted medical SR processes for software engineering and developed a review protocol, based on the clinical SR strategy: Population, Intervention, Comparison and Outcome (PICO) (3.1).</p> <p>The popularity and importance of SR has seen sustained growth in software engineering, as well as in disciplines such as clinical medicine, environmental science, social policy and education. SR involves systematic storage, management, validation and analysis of large quantities of data, so can be error prone (e.g., misclassification or erroneous exclusion of studies) and time consuming; in addition, problems with study selection, data extraction and data synthesis can lead</p>		

to biased results (3.3, 3.4). Many software tools exist to support SR in software engineering and other disciplines, these include: spreadsheets, reference managers, statistics packages, and purpose-built tools supporting most stages of the review process. However, whilst these tools reduce manual processing errors, until development of the SRToolbox there was no systematic way to evaluate tools, or to select the appropriate tool for a specific SR.

The first step in developing the SRToolbox was to create a SR-tool evaluation framework (3.3, 3.4). This required significant evidence-based research, including a mapping study that identified SR support tools (3.5), a feature analysis in which software engineering users evaluated SR tools to derive a set of ranked features, and a cross-domain survey of researchers using SR (3.4). Working with Marshall (Keele PhD student 2012-2016, York Health Economics Consortium 2015-2018; Newcastle University 2019 onwards), the team created SRToolbox to encapsulate the findings, the framework and a catalogue of evaluated SR tools.

The SRToolbox, which now references over 140 SR tools, has been freely available since 2015 (3.6). The rigorous tool evaluation, using well-founded feature analysis; and the capability to filter tools according to desired features, makes SRToolbox an important advance on previous SR tool-inventories.

3. References to the research (indicative maximum of six references)

3.1 Kitchenham, B. and Charters, S., 2007. Guidelines for performing systematic literature reviews in software engineering. EBSE Technical Report EBSE-2007-01 (https://www.elsevier.com/_data/promis_misc/525444systematicreviewsguide.pdf)

3.2 Barbara A Kitchenham, Tore Dyba, Magne Jorgensen, 2004. Evidence Based Software Engineering, *Proceedings of the 26th international conference on software engineering*, Pages. 273-281, IEEE Computer Society, (<https://doi.org/crc8n5>)

3.3 Budgen, D., Brereton, P., Drummond, S. and Williams, N., 2018. Reporting systematic reviews: Some lessons from a tertiary study. *Information and Software Technology*, 95, pp.62-74. (<https://doi.org/10.1016/j.infsof.2017.10.017>)

3.4 Chris Marshall, Barbara Kitchenham and Pearl Brereton, 2018. [Tool Features to Support Systematic Reviews in Software Engineering – A Cross Domain Study](#), *e-Informatica Software Engineering Journal*, vol. 12, no. 1, pp. 79–115. (<https://doi.org/10.5277/e-Inf180104>)

3.5 C. Marshall and P. Brereton, 2013. Tools to support systematic literature reviews in software engineering: A mapping study. *Proceedings of ACM/IEEE International Symposium on Empirical Software Engineering and Measurement*. IEEE Computer Society Press, pp. 296–299. (<https://doi.org/10.1109/ESEM.2013.32>)

3.6 Marshall, C. and Brereton, O.P., 2015. Systematic review toolbox: a catalogue of tools to support systematic reviews (<http://systematicreviewtools.com/>)

Grants:

1. Barbara Kitchenham, EPSRC, Managing software risks across a portfolio of projects, 01.03.1999 - 28.02.2002, £116,211 (**GR/M33709/01**)
2. Barbara Kitchenham, EPSRC, Methods for valid analysis of software datasets, 02.01.1997 - 31.12.1999, £70,552 (**GR/L28371/01**)
3. Pearl Brereton, EU FP7, E-RISK: Evidence-based risk management in global software development projects, FP7-PEOPLE-IIF, 01.12.2010 - 30.11.2012, £156,060 (**Grant agreement ID: 253754**)
4. Pearl Brereton, EU FP5, Clear and reliable information for integration (CLARIFI), 01.01.2000 - 31.12.2002, £153,458 (**Grant agreement ID: IST-1999-11631**)
5. Pearl Brereton, Barbara Kitchenham, EPSRC, Evidence-based practices informing computing (EPIC), 01.05.2007 - 30.04.2009, £180,383 (**EP/E046983/1**)

4. Details of the impact (indicative maximum 750 words)

The impact of SRToolbox derives from its tool evaluation framework, its support for selection of appropriate SR tools, and the emergence of a community of practice for SR.

The SRToolbox has established a global community, with many users in Europe and North America (5.5). which recommends tools to add, attracting and supporting new SR researchers (5.5). The SRToolbox website (3.6) receives over 4000 unique monthly visits (5.7); the associated twitter account is actively sought (1:100 ratio *following* to *followers*: 5.7). SRToolbox activity is increasing (5.5: over 40 tweets a month mention SRToolbox, from accounts not connected to @SRToolbox). The developer hub within the SRToolbox environment, provides training and shared data sets for tool developers.

SRToolbox has had considerable impact in traditional areas of health and policy review. It is recommended by a number of organisations, including: Cochrane, British Medical Journal, Royal College of Veterinary Surgeons, NHS National Institute for Health Research, the Swedish Agency for Health Technology Assessment, the Centre of Excellence for Development Impact and Learning (CEDIL) and Massachusetts General Hospital (5.1, 5.2, 5.3, 5.4). Users include clinical researchers, statisticians and information specialists and it is used to support evidence-based public health, medicine and healthcare (5.5, 5.6).

Overcoming the challenges of Systematic Review

SR requires rigorous identification and synthesis of evidence, to inform decision-making, policy and practice. "Systematic reviews are a time consuming, logistically challenging and labour-intensive undertaking" (5.1). Although there are many software tools to support SR, before the 2015 launch of SRToolbox, there was no systematic way to evaluate or compare SR tools, and review sites struggled to keep up (5.5, 5.6).

The SRToolbox provides free online access to a catalogue of systematically evaluated SR tools. The toolbox is regularly updated, with new tools and in response to user requests (5.6, 5.8). The SRToolbox interface allows users to search a comprehensive list of features, established by the underpinning research, supporting informed selection from over 140 tools (5.8). A SR reviewer reports, "*It is difficult to see the trees through the SR tools forest. SRToolbox helps to give a bit of an overview of what choices there are.*" (5.6).

Supporting the production of high-quality SRs

Cochrane, a global network dedicated to producing high-quality SRs to inform global health decision-making, has replaced its web catalogue of SR tools with a recommendation to use SRToolbox to identify appropriate tools to support its reviewers (5.1). Cochrane notes the increased efficiency and time saved in both new reviews and updating of a review (5.4). Cochrane reviews making use of SRToolbox, such as the 2018 review of patient-mediated interventions that aimed to improve professional healthcare practice, have been used to inform shared decision-making tools (5.9). For example, a Senior Advisor from the Norwegian Institute of Public Health (NIPH) reports that SRToolbox supports review-scoping and overviews of reviews, as well as rapid reviews and reports, and is used in the commissioning, planning and execution of reviews (5.9).

SRToolbox also provides a search function for good, free SR tools. An NHS librarian reports, "*I like the way you can search by cost, this is the usual sticky subject for NHS customers as NHS Trusts are rarely able to afford subscriptions to software packages.*" (5.6). Using the SRToolbox evaluation framework, health librarians in North Carolina undertook independent evaluations of free tools, producing recommendations on free tools for SR (5.10).

Supporting these specific cases, an online survey of users produced 26 responses, of which 54% agreed that SRToolbox improved their awareness of technology to support SR and evidence

synthesis, whilst 65% agreed that SRToolbox allowed them to identify tools supporting SR (5.6). Twitter analysis shows that 61% of tweets express positive sentiments, whilst individual tweets confirm that SRToolbox has raised awareness about the availability of software tools at different stages of SR reviews (5.5). SRToolbox has enabled improved tool development and sharing of best practice in tools. Evaluation and community discussion highlights issues with generic SR tools that do not meet SR users' needs, and duplicated tool provision, as well as enabling consolidation of tools (5.5).

SRToolbox gives confidence to systematic reviewers that tools used in evidence searching are suitable and effective for the specific review being undertaken (5.8). Having access to complementary tools via SRToolbox reduces the chance that relevant findings are missed, thereby improving the reliability of SR findings, used, for instance, to develop guidance and policy in clinical, government and NGO settings (5.9).

5. Sources to corroborate the impact (indicative maximum of 10 references)

5.1 Cochrane recommendation of Systematic Review Toolbox

5.2 Organisations that have recommended the SRToolbox (posted on webpages and social media accounts).

5.3 Booth, Sutton and Papaioannou (2016) Systematic approaches to successful literature review. Sage (cited by 1112)

5.4 Thomas J, Chandler J, Cumpston M, Li T, Page MJ, Welch VA (editors). Cochrane Handbook for Systematic Reviews of Interventions version 6.0 (updated August 2019) see Chapter 2: Planning a Cochrane Review and Chapter 4: Searching for and selecting studies.

5.5 Twitter analytics of @SRToolbox and tweets by other accounts mentioning SRToolbox, includes identification of users, where they are from, count of tweets, sentiment analysis of related tweets and examples of related tweets.

5.6 Online survey of SRToolbox users (shared through @SRToolbox)

5.7 Systematic Review Toolbox Webpage and Twitter account metric data.

5.8 Testimonial from Associate Director of York Health Economics Consortium (YHEC).

5.9 Testimonial from Senior advisor from Norwegian Institute of Public Health

5.10 Blog by Health Librarians (North Carolina, USA), 15/02/2018, Free systematic review software.