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Mapping current research and future directions of Design Literacy with systematic quantitative literature review (SQLR)

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Abstract

Design literacy is an emerging research field that is gaining attention among scholars today. Credit goes to the growing acceptance of design thinking in various disciplines beyond design. Design literacy develops natural abilities in everyone to solve real-world, wicked problems by supporting the cognitive development of concrete (making things) and iconic (making meanings) modes of cognition. The author argues for embedding design literacy in every educational level, particularly across disciplines in higher education. To gain insight into the state of scholarly discourse around design literacy in educational contexts, a systematic quantitative literature review (SQLR) was conducted using 12 databases to map its research direction and define its characteristics. The SQLR revealed several findings. First, the foundations of design literacy are grounded in general education and design education. Second, publications were meagre but well represented by the secondary and higher education level. Finally, two thematic directions were observed - *design literacy for making things* is the situated practice in secondary education while *design literacy for making meanings* is for higher education. This SQLR serves as a benchmark review and a starting point to initiate scholarly discourse on design literacy as it aims to contribute to the advancement of research in the field.

Keywords

design literacy, digital learning, participatory culture, systematic quantitative literature review (SQLR), making things, making meanings

Introduction

Digital technology enabled learning and select human activities to move online, especially in pandemic times. However, not everyone was prepared with requisite skills and mindset to manage the digital shift. The move to digital learning and engagement requires new ways of learning or literacy to participate effectively in the digital environment (Lankshear & Knobel, 2007). There are many kinds of literacy that emerged in the information age (Leu et al., 2015) but design literacy is argued by the author as more appropriate to facilitate this transition.

Design literacy is a relatively new term and defining it is challenging and contentious. There is a caveat to this attempt whilst a definition of some kind may emerge from the literature itself. To give context to the term 'design literacy', design as a word and a discipline is defined subsequently. It is used as a noun and a verb to refer to the product or the process of making (Balsamo, 2009). Design is embodied in the artefact in its operation and practice (Jones, 2014). Design as a discipline is the third pillar of knowledge after the sciences and the humanities (Archer, 1979; Cross, 1982). Design exemplifies the practice of *learning by doing* (Archer, 1979; Pacione, 2010; Poggenpohl, 2008; Sheridan & Rowsell, 2010) which is what people do as they

rework materials and meanings to adapt their needs around the growing ubiquity of digital technology. Design is inherently anthropocentric (Archer, 1979) or human centred (Burdick & Willis, 2011; Pacione, 2010). Design's intrinsic ability to put people's wellbeing and interest at the core of what Margaret Mead (1978) refers to as a *radical cultural change* or digital revolution makes design an appropriate platform to support the emergence of a literacy that is learner centred (Jones, 2014) inside the digital environment. Furthermore, the acceptance of design thinking (Bower, 2017; Brown, 2008; Donaldson & Smith, 2017; Razzouk & Shute, 2012) as a creative tool of inquiry in problem solving is now applied to other fields beyond the practice of design (Adikari et al., 2013; Dunne & Martin, 2006; Liedtka, 2014; Thi-Huyen et al., 2021). It elevated the application of design's intrinsic qualities to address the emerging concerns of digital learning (Jones et al., 2021; Lotz et al., 2018; Marshalsey & Sclater, 2020) and engagement in the knowledge economy that it fostered.

Design Literacy Defined

Liv Merete Nielsen and Karen Brænne (2013) defines design literacy as the competence of communicating meaning, function and quality to empower anyone using multiple modes of knowledge to produce material culture. Eva Lutnaes (2020) extends this concept to advocate for changes to Years 1-10 curriculum to introduce and advance socioecological sustainability awareness in design education. Their context of design literacy is situated in secondary and primary education respectively. On the other hand, design literacy for Chris Pacione (2010, 2017), are the skills in inquiry and observation, evaluation and synthesis to solve complex problems with design not only in the physical world but also in the digital environment. He situates design literacy within the context of higher education and beyond. It is important to stress that their concept of design literacy is for everyone, especially those coming from non-design backgrounds. Design literacy is not for those who are studying to become professional designers as they already have the design faculties and have acquired the design fluency to practice design as a profession. Design literacy is envisioned by the author as a model of design education to introduce and institutionalize the designerly ways of knowing (Cross, 1982), designerly ways of thinking (Pacione, 2010) and designerly stance to inquiry (Christensen et al., 2016) in general education, especially for non-design disciplines in higher education.

Designerly way of knowing according to Nigel Cross (1982) is the ability to: a) identify the wicked nature of real-world problems, b) use solution-focused approach to solve these problems, c) use design thinking (aka constructive or abductive thinking) in generating solutions, d) transform abstract ideas to concrete *objects* (or solutions) through the process of *making*, and e) apply the skill of *making objects* to *making meanings* (read and write in object languages) to make sense of the process. Cross argues for the justification of design in general education as: a) design develops natural abilities to solve complex, real-world problems, b) design supports cognitive functions in the *making of things* (concretizing modes) to *making of meanings* (iconic modes) and, c) design supports the development of non-verbal thoughts and communication or *tacit knowledge*. These are the aims of design as a literacy for everyone.

Designerly ways of thinking according to Pacione (2010) is using *Look-Understand-Make* process (*Praxis of Design Thinking)* to understand problematic situations. *Look* is the process of using inquiry and evaluation to gain empathy or informed perspective to build insight on a problem. *Make* is the process of forming and concretizing solutions in a series of

experimentation. In between these steps is *Understand* or the process of *making sense of things* or *making meaning*s as one improves on a solution from previous iterations.

Designerly stance to inquiry according to Kasper Skov Christensen et al. (2016) is an important part of design literacy. It is the precondition for initiating design thinking process in a problematic situation. The current education system is designed to produce routine experts among graduates. Routine experts see real-world problems as tame and well-defined. However, real world problems are wicked in nature. By developing the students' designerly stance to inquiry (aka reflective inquiry), design literacy prepares them to take on real-world problems with an empathic, investigative, and inquisitive approach in problem-solving.

Design literacy in the context of this study is the competency to develop skills in *making things* (concretizing mode) and *making meanings* (iconic mode) using designerly ways of knowing, thinking, and inquiring. These learning dispositions are crucial to develop tacit knowledge that is essential in today's knowledge economy. The knowledge economy is built on knowledge intensive activities requiring high-level skills and tacit knowledge, or the skills in implementing codified knowledge (Pettinger, 2017; Polanyi, 1962). Tacit knowledge comes from learning-by-doing and is the signature pedagogy of design (Crowther, 2013; Poggenpohl, 2008).

The digital environment is a place that supports learning-by-doing and prepares students for a world that relies increasingly on digital technologies. Inside this digital space, they design with materials both physical and virtual using multimodal forms of text such as images, audio, video or interactive content (Apperley & Beavis, 2013; Cazden et al., 1996; Victoria-State-Government, 2022). These variegated elements support non-linear communication and opens new forms of *meaning making* using different medium (SMS, emails, wikis, blogs, vlogs, etc), various formats (JPEG, PNG, GIF, PDF, SVG, MP4, etc) and diverse social media (Tiktok, Snapchat, Instagram, Youtube, Facebook, etc.).

Design literacy develops the students' learning dispositions that support their engagement inside the digital environment. Digital engagement is unconstrained by time nor distance, virtual and networked, with its own social norms embodied in participatory culture (Jenkins, 2009). Participatory culture is a phenomenon in the digital environment where experienced participants pass knowledge to novices as they create and share digital culture. It recalls to mind the mentor-apprenticeship relationship of traditional design studios (Poggenpohl, 2008). Design as a convergent medium has the facility and agency of supporting meaning making in the consumption, production, and distribution of digital culture in communities of practice like participatory culture. As students engage with digital media, they produce digital culture and foster learning and engagement inside the digital environment. The author reaffirms the nuanced role of meaning-making that design literacy engenders. This observation is shared with scholars in the field (cf. Kalantzis & Cope, 2018; Sheridan & Rowsell, 2010).

Research Stimulus

In 2012, the European Design Leadership Board (EDLB) of the European Union released directive #20 which recommends "to raise the level of design literacy for all the citizens of Europe by fostering a culture of *design learning for all* at every level of the education system" and #21 to "support the development of design competencies for the 21st century by embedding the strategic role of *design across disciplines in higher education*" (Thomson & Koskinen, 2012, p. 73) (emphasis supplied). This highlights the need for design literacy in all

levels of education and across disciplines in higher education. This directive is the needed stimulus for design literacy to prosper, particularly in its emphasis on higher education.

Why a systematic quantitative literature review (SQLR)?

A scoping exploration of literature around design literacy revealed an apparent absence of SQLR. Hence, the aims of this article are a) to map the breadth of literature on design literacy as a benchmark review by using SQLR, b) to establish baseline information and track the use of 'design literacy' in general education, particularly in higher education, and c) to test if SQLR is an appropriate method of inquiry than narrative review to identify themes, directions, or capture characteristics of design literacy as an emerging research topic.

A narrative review relies on the credibility of the reviewer's expertise on the topic and may oftentimes be open to reviewer's biases. In the absence of topical expertise of early career researchers or veteran researchers working on a new topic, SQLR provides an alternative means of gathering relevant information for building new knowledge on a research topic. It requires entry level skills of quantifying information based on a specific set of criteria and systematic review of databases. In summary, SQLR relies on objective, transparent criteria to allow reproducibility of results (Collins & Fauser, 2005; Cook et al., 1997; Pickering & Byrne, 2014).

Research Direction Amendment

Two questions were raised at the start of the search: a) What is the state of design literacy and its significance in higher education? and b) Will SQLR be a viable mode of inquiry to review literature of this emerging research topic? A scan of literature during the initial scoping review uncovered two results: a) the meagre quantity of design literacy research on higher education, and b) the availability of research on secondary and primary education, and the educators in these sectors as well as purely conceptual frameworks with no participants in the study. The author's research direction thereafter was amended to capture instead a bigger picture of design literacy's development in general education to inform the author's interest in higher education. This strategic decision is important because higher education provides the leadership in curricular changes in response to societal transformations and market demands (Wright et al., 2013). The primary and secondary education, and the industry, move in line with higher education's initiatives. An internationally competitive higher education system sustains the high standards of living in a country like Australia where international education is its fourth largest export, generating $40.3 billion income in 2019, with approximately 70% ($27.8 billion) is attributed to higher education sector's contribution (Universities-Australia, 2020, p. 42) to their economy.

Research Findings

Midway through the review, the advantages of employing SQLR became apparent over narrative review: a) the agency it provides to arrive at a quantifiable and reproducible result for others to undertake, and b) its suitability for "emerging areas and for areas where methodical approaches are so diverse that there is limited potential for other types of quantitative reviews such as meta-analysis" (Pickering & Byrne, 2014, p. 539). By employing SQLR, the author was able to identify three major findings. First, design literacy originates from two distinct discipline: General education represented predominantly by the secondary education sector, and Design education. Second, design literacy is defined by its situated practices: in general education, it is *Design Literacy for Non-designers* (DLN) while in design education, it is *Design*

Literacy for Designers (DLD). Finally, under DLN's scope, two emergent themes were identified: *design literacy for making things* define design literacy in secondary education while *design literacy for making meanings* define design literacy in higher education. The implications of these findings are discussed in the *Results* and *Discussion* section.

Methodology

Databases and search phrase

A systematic, quantitative literature review (SQLR) was conducted using twelve databases namely, Google Scholar, ProQuest, Griffith Library Catalogue, SpringerLINK, JSTOR, Web of Science, Taylor and Francis, SAGE, Scopus, ERIC, Design and Applied Arts Index, and Bloomsbury Design Library. The search phrase used was ("design literacy") AND ("higher education" OR HE OR tertiary OR "university students") for all databases except for Web of Science where the search term used was "design literacy" because the complete search phrase generated no result. All databases except Bloomsbury Design Library produced results. These results were refined using the filters *last 10 years, peer reviewed,* and *journal article* found in each database. The number of journal articles came down to 225 after the refinements. Furthermore, the number of journal articles were reduced to 41 after reviewing the title and abstract. Refer to Table 1: Database Search Result for details. Refer to Appendix A for complete results of Database Search.

Table 1: Database Search Result

Resource	Search Terms	Refinements	Papers used
Google scholar	("design literacy") AND ("higher education" OR HE OR tertiary OR "university students")	Last 10 years - 1210 Peer reviewed - 22 Journal article - 22	16
ProQuest	("design literacy") AND ("higher education" OR HE OR tertiary OR "university students")	Last 10 years - 361 Peer reviewed - 52 Journal article - 52	6
Griffith Library Database	("design literacy") AND ("higher education" OR HE OR tertiary OR "university students")	Last 10 years - 137 Peer reviewed - 68 Journal article - 66	8
SpringerLink	("design literacy") AND ("higher education" OR HE OR tertiary OR "university students")	Last 10 years - 109 Peer reviewed - 18 Journal article - 18	1
JSTOR	("design literacy") AND ("higher education" OR HE OR tertiary OR "university students")	Last 10 years - 27 Peer reviewed - 24 Journal article - 17	1
Web of Science	("design literacy")	Last 10 years - 29 Peer reviewed - 18 Journal article - 18	2
Design and Applied Arts Index (DAAI)	("design literacy") AND ("higher education" OR HE OR tertiary OR "university students")	Last 10 years - 15 Peer reviewed - 12 Journal article - 12	2

Taylor and Francis	("design literacy") AND ("higher education" OR HE OR tertiary OR “university students”)	Last 10 years - 12 Peer reviewed - 12 Journal article - 12	2
SAGE	("design literacy") AND ("higher education" OR HE OR tertiary OR “university students”)	Last 10 years - 6 Peer reviewed - 6 Journal article - 6	1
Scopus	("design literacy") AND ("higher education" OR HE OR tertiary OR “university students”)	Last 10 years - 3 Peer reviewed - 1 Journal article - 1	1
ERIC	("design literacy") AND ("higher education" OR HE OR tertiary OR “university students”)	Last 10 years - 1 Peer reviewed - 1 Journal article - 1	1
Bloomsbury Design Library	("design literacy") AND ("higher education" OR HE OR tertiary OR “university students”)	Last 10 years - 0 Peer reviewed - 0 Journal article - 0	0
Total		Journal articles - 225	41

The articles covering secondary and primary education were part of the research set produced from the search. During the initial scoping review, the author re-assessed the research direction after finding only a few journal articles on higher education was available. By including journal articles that discussed other cohorts like secondary and primary education, the systematic search became more inclusive and descriptive of design literacy’s situated practices in the whole education spectrum.

Selection criteria

The inclusion criteria were: 1) original, peer-reviewed English journal articles with *design literacy* in its title, abstract, or body of literature, 2) journal articles that have specific student cohorts in their studies i.e., in primary, secondary or higher education, or the educators in these cohorts, or 3) journal articles that discussed conceptual framework or experts’ opinion pieces about design literacy without student cohorts, and 4) journal articles that discuss design literacy as part of general education. All journal articles were reviewed and further screened by removing 1) book chapters, conference proceedings or theses, etc otherwise known as *grey literature*, 2) journal articles where *design* was used as a verb *to design* literacy instead of the noun, *design literacy*, 3) journal articles where *design literacy* was only found in the bibliography or references, 4) journal articles that used design literacy incorrectly as a term referring to other meaning like *orientation* or *communication*, and 5) journal articles that have very specific type of literacy like *game design literacy*. Journal articles were considered if they use more complex phrases like *digital design literacy* or *critical digital design literacy*, or a term that is synonymous like *aesthetic knowledge*.

Table 2 Inclusion Criteria, Exclusion Criteria and Exemptions

Inclusion Criteria
1. Peer-reviewed English journal articles with *design literacy* in its title, abstract or body of literature
2. Journal articles with student cohorts i.e., primary, secondary, or higher education, or its educators

3. Journal articles that discuss conceptual framework or experts' opinion pieces about design literacy
4. Journal articles that discuss design literacy as part of general education
5. Journal articles that were published from 1 January 2010 to 15 December 2020
Exclusion Criteria
1. Book chapters, conference proceedings, theses, etc. otherwise referred to as *grey literature*
2. Journal articles where *design* was used as a verb *to design* literacy
3. Journal articles where design literacy was only found in the bibliography or reference section
4. Journal articles that used *design literacy* differently to refer to another meaning like orientation, etc
5. Journal articles that have very specific type of literacy like *game design literacy*
Exceptions
1. Journal articles using complex phrases like *digital design literacy* or *critical digital design literacy*
2. Journal articles that uses synonymous term like *aesthetic knowledge*

The journal articles were collected from 13-15 December 2020. Publications included in the search were from 1 January 2010 to 15 December 2020. Journal articles before or beyond the inclusive dates were not included in the review. In total, 41 journal articles were eligible for review after passing through the selection criteria. The literature search was limited to three days as algorithm of search engines change periodically without warning. The 41 journal articles were reviewed and completed in January 2021. There were 25 journal articles excluded from the second review in February 2021 leaving only 16 journal articles for the final SQLR review.

SQLR Flowchart

The method of selection used the *preferred reporting items for systematic reviews and meta-analyses* (PRISMA) (Moher et al., 2010) flowchart in Figure 1: SQLR Methodology Flowchart. The flowchart has 4 stages namely, *Identification, Screening, Eligibility* and *Included*. Under the *Identification* stage, the search phrase ("design literacy") AND ("higher education" OR HE OR tertiary OR "university students") was used in all database search except for Web of Science where ("design literacy") sufficed. Records identified through the database search were added to records that were identified by the author from other sources. In the *Screening* stage, all records were screened for duplicates leaving 246 journal articles to go through screening by title and abstract. The 225 journal articles that passed through this screening underwent further review by removing journal articles outside the inclusive dates, grey literature, not written in English, citations only, or full text was not available from regular online research. There were 41 full-text journal articles that reached the *Eligibility* stage but 25 of these were excluded based on listed criteria. In total, 16 journal articles were eligible for review for quantitative synthesis in the *Included* stage.

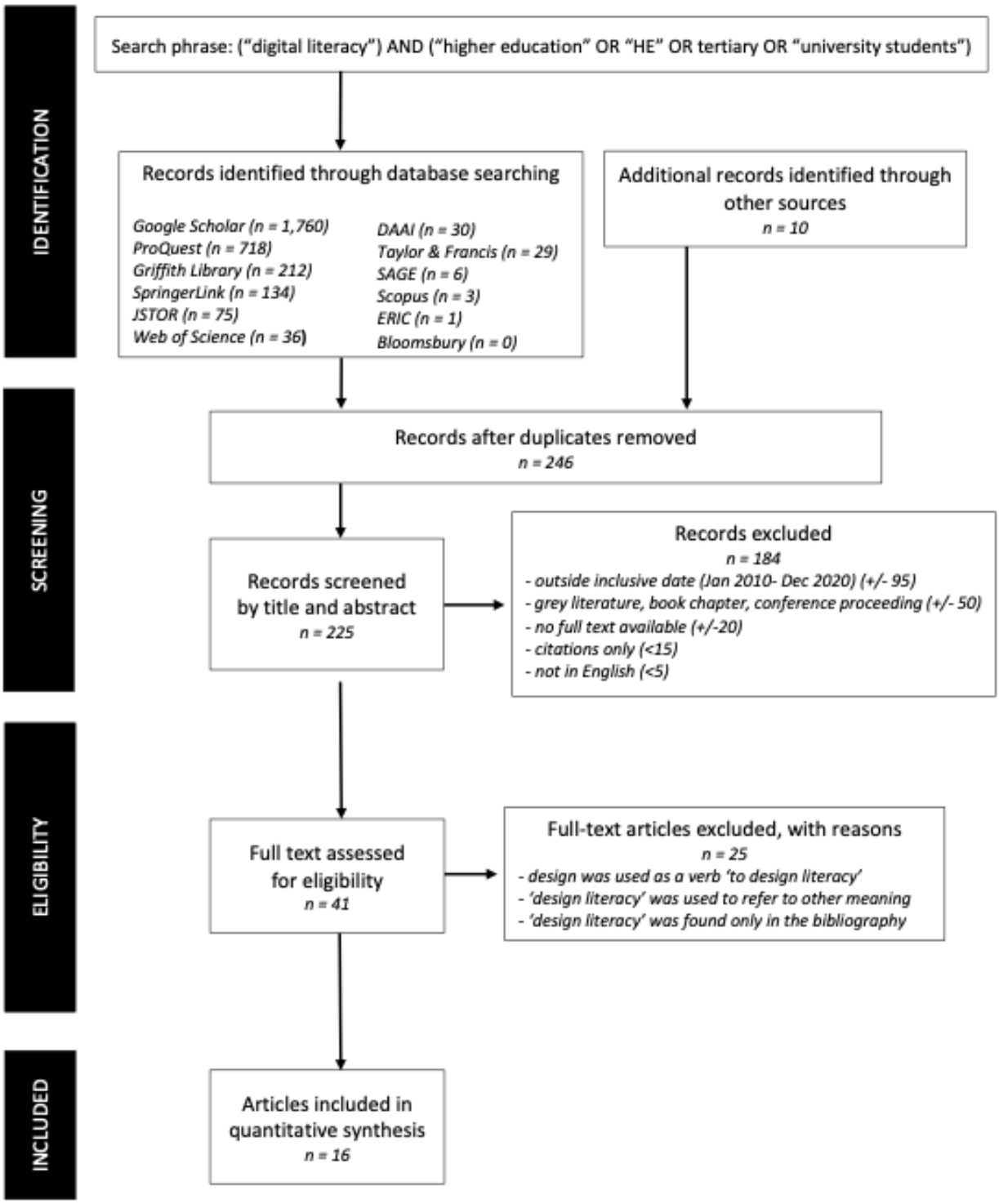

Figure 1: SQLR Methodology Flowchart

Results

The SQLR was conducted to gain better understanding of the state of design literacy research by identifying thematic directions and emergent gaps. The 16 journal articles gleaned from the 12 databases were encoded in Excel spreadsheet using relevant Pickering systematic reading criteria (Pickering, 2021) based from their seminal journal article on SQLR (Pickering & Byrne, 2014). The findings were tabulated under the categories *Publication Year, Country of Origin /*

Publication, Disciplinary Field and Type of Design Literacy, Broad Topics, Specific Topics, Research Methodology, and *Emergent Themes*. New categories were added or expanded during the review process. For example, a new category *Sector* was added to represent the primary, secondary and higher education levels. It was later expanded to include new categories like *Educator* and *Concepts* to accommodate new findings from some journal articles that do not cover student as subjects in the study but discusses capacity building among educators, or conceptual frameworks on design literacy. The decision to place the 16 articles as columns was strategic because they remained constant throughout the review. The variables were placed in rows to make addition or revision more manageable during the review process. Affixing '1' as value for each identified category resulted to quantifiable data after all the information were listed in the table. Refer to Table 3: Table of Results.

Table 3: Most frequent is highlighted and in bold letters

CATEGORIES	DETAILS	SELECTED 1 Ehret et al.	2 Gravel et al.	3 Haag & Marsden	4 Lim et al.	5 Yorgancioglu &	6 Christensen et al.	7 Christensen et al.	8 Maus	9 Maus	10 Rahimi et al.	11 Lerner	12 Lutnaes	13 Nielsen & Braenne	14 Pacione	15 Pangrazio	16 Wright et al.	TOTAL
Publication Year	2020					1							1					2
	2019								1	1								2
	2018	**1**		**1**				**1**			**1**	**1**					**1**	**6**
	2017		1															1
	2016						1									1		2
	2013													1				1
	2011				1													1
	2010														1			1
Country of Origin / Publication	Australia															1	1	2
	Canada										1							1
	Denmark						1	1										2
	Germany			1														1
	Norway								**1**	**1**			**1**	**1**				**4**
	South Korea				1													1
	Turkey					1												1
	USA	**1**	**1**									**1**			**1**			**4**
Disciplinary Field and Type of Design Literacy	**Design (Design literacy for Designers)**																	5
	Architecture					1												1
	Industrial Design				1													1
	Art & Design											1		1	1			3
	Education (Design literacy for Non-Designers)																	**11**
	General education	1											1			1		3
	Secondary education						**1**	**1**	**1**	**1**	**1**						**1**	**6**
	STEM education		1	1														2
Broad Topics	Affect and participatory culture	1																1
	Maker spaces literacy		1															1
	Empathy			1														1
	Interaction design				1													1
	Design education					1												1
	Designerly stance towards inquiry						1	1										2
	Design literacy for sustainability								1	1				1				3
	Visual-spatial skill and Design literacy											1						1
	Design literacy for primary level												1					1
	Design literacy for secondary level						**1**	**1**	**1**	**1**	**1**		**1**	**1**				**7**
	Design literacy for all														1	1		2
	Design literacy as production of digital artifacts															1		1
	Design literacy for educators																1	1
Specific Topics	Booktubers	1																1
	STEM literacies in maker spaces		1															1
	Use of persona in user-centred design			1														1
	Somaesthetics				1													1
	Critique and its role in design literacy					1												1
	Design literacy tool (DeL)						1											1
	Fablab							1										1
	Case Keramikk								1									1
	Case Sveip (bentwood box)									1								1
	Interest-driven literacy										1							1
	Visual-spatial ability and problem-solving skill											1						1
	Responsible design literacy												1					1
	Design for longer-lasting products													1				1
	Design literacy for non-designers														1			1
	Critical digital literacy to digital design literacy															1		1
	Design immersion program for educators																1	1
Research Methodology	Case Study	1	1	1	1	1	1	1	1	1	1							10
	Interview / Focus Group	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**						**1**	**11**
	Narrative / Literature Review											1	1	1	1	1	1	6
Sector	Tertiary	1	1	1	1	1												5
	Secondary						**1**	**1**	**1**	**1**	**1**		**1**				**1**	**7**
	Primary												1					1
	Educators										1						1	2
	Concepts											1		1	1	1		4
Emergent Themes	**Design literacy for *making things* in physical world**		**1**			**1**	**1**	**1**	**1**	**1**			**1**	**1**			**1**	**9**
	Design literacy for *making meanings* in digital environment	1		1							1				1	1		5
	Both				1													1
	Neither											1						1

Authors and Journal Articles

The most cited article from the SQLR was Pacione's (2010) with five authors in the SQLR citing his article. Nielsen & Brænne (2013) and Christensen et al. (2016) came second with three citations each. Refer to Table 4: Author by Author Citation.

Table 4: Most frequent is highlighted and in bold letters

AUTHORS	YEAR	SELECTED ARTICLES															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
		Ehret et al.	Gravel et al.	Haag & Marsden	Lim et al.	Yorgancioglu & Tunali	**Christensen et al. 2016**	Christensen et al. 2018	Maus 2019a	Maus 2019b	Rahimi et al.	Lerner	Lutnaes	**Nielsen & Braenne**	**Pacione**	Pangrazio	Wright et al.
Ehret et al.	2018																
Gravel et al.	2017																
Haag & Marsden	2018																
Lim et al.	2011																
Yorgancioglu & Tunali	2020						1								1		
Christensen et al.	2016														1		
Christensen et al.	2018														1		
Maus	2019a						1			1				1	1		
Maus	2019b								1					1			
Rahimi et al.	2018																
Lerner	2018																
Lutnaes	2020						1	1			1	1		1	1		
Nielsen & Braenne	2013																
Pacione	2010																
Pagrazio	2016																
Wright et al.	2018																
TOTAL							**3**	**1**	**1**	**1**		**1**		**3**	**5**		

The author considers Pacione's article as a landmark article for the following reasons: a) this is where *design literacy* was clearly declared as a literacy for everyone and positions design as the human-centred literacy for the digital age, b) Pacione argues that what arithmetic has done to the industrial age, design literacy can do for the digital age and the knowledge economy, and c) its publication year (2010) has influenced the author's decision to scope this SQLR to a decade (2010-2020) of peer-reviewed articles after its publication year. The European Design Leadership Board released its design directive two years after Pacione's publication, reflecting these milestones of design literacy within the inclusive dates identified.

Publication Year

The highest number of publications in a year happened in 2018 with 6 journal articles from 5 countries: USA (2), Australia, Canada, Denmark, and Germany. There were two publications in 2020, 2019 and 2011 while the rest of the years have one journal article published except in 2015, 2014 and 2012. The SQLR showed design literacy publications peaked in 2018 and had

maintained momentum onwards. It indicates the interest on the topic is steady if not on an increasing trend.

Country of Origin / Publication

The inclusion of *Country* as a category of interest is to highlight the origin of research and publication trend in this area. Location may be a factor in influencing conceptual development or dissemination of trends in design literacy. There were 8 countries where the journal articles were published. Norway and the USA each have four publications. Denmark and Australia each have two published articles. Countries with single publication are Canada, Germany, South Korea and Turkey. Results show that European countries like Norway and Denmark have the most publications on design literacy and this can be attributed to the European Design Leadership Board's (EDLB) design directive to promote *design learning for all* at all levels of education and *across disciplines in higher education*. This is further discussed in the *Discussion* section.

Disciplinary Field and Type of Design Literacy

The disciplines of Design and Education are the two broad areas where design literacy research originates. The Design discipline has a total of 5 articles represented by the fields of Art & Design education (3), Architecture (1) and Industrial Design (1). The author refers to this cohort as *Design Literacy for Designers (DLD)*. The Education discipline has 11 articles represented by secondary education (6), general education (3) and STEM education (2). The author refers to this cohort as *Design Literacy for Non-Designers (DLN)*. This finding positively illustrates the bifurcation of origin and development of design literacy in the Design and Education disciplines respectively. Refer to Table 5: Field and Type for details.

Table 5: Most frequent is highlighted and in bold letters

CATEGORIES	DETAILS	SELECTED ARTICLES																TOTAL
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
		Ehret et al.	Gravel et al.	Haag & Marsden	Lim et al.	Yorgancioglu &	Christensen et al.	Christensen et al.	Maus	Maus	Rahimi et al.	Lerner	Lutnaes	Nielsen & Braenne	Pacione	Pangrazio	Wright et al.	
Disciplinary Field and Type of Design Literacy	Design (Design literacy for Designers) (DLD)																	5
	Architecture					1												1
	Industrial Design				1													1
	Art & Design											1		1	1			3
	Education (Design literacy for Non-Designers) (DLN)																	**11**
	General education	1											1			1		3
	Secondary education						**1**	**1**	**1**	**1**	**1**						**1**	**6**
	STEM education		1	1														2

A curious question arouse why design literacy is found in Education, particularly why the Education discipline has the most journals on design literacy. A retrospective view explains why: Design literacy's emergence was supported by an earlier type of literacy enabled by digital technologies referred to as 'digital literacy'. Digital literacy was used as a term to mark the move of information sciences or library resources to the digital era (Bawden, 2001). The advocates of digital literacy mostly came from the fields of learning and literacy which are the

domains of the Education and English department, and to some extent, Technology. Burdick and Willis (2011) states that these disciplines also refer to digital literacy as *multimedia literacy*. They cited literacy advocates like the *Partnership for 21st Century Skills*, *EDUCAUSE*, and *New Media Consortium*, quoting the latter's definition of 21st century literacy as "the set of abilities and skills where aural, visual, and digital literacy overlap. This includes the ability to understand the power of images and sounds, to recognize and use that power, to manipulate and transform digital media, to distribute them pervasively, and to easily adapt them to new forms" (New-Media-Consortium, 2005, p. 2) . Burdick and Willis (2011) argue that in many ways, the 21st century literacy they advocate is very much like designing. Burdick and Willis further suggest that the combined skills of designerly ways of knowing (Cross, 1982), and the specialised fields of communication, interface design, and interaction design, provide the vital link to shift the study of multimedia literacy to the field of design. This observation brings to light design's connection to learning in the digital domain. Consequently, the foremost finding from the SQLR confirms Education and Design as the disciplines where the design literacy articles originated. This will be discussed further under *Emergent Themes*.

Broad and Specific Topics

There were 13 broad topics that branched to 16 specific topics from the journal articles in review. Seven journal articles discussed more than one topic on the list. The most discussed topic was design literacy for sustainability focusing on secondary education curriculum. This will be discussed further in the *Discussion* section. The broad and specific topics were summarized from reviewing all 16 articles' *Abstract* and content. They were easily identified from the articles' narrative. The identification of specific topics took several evaluation processes involving the author and principal supervisor to prevent reviewers' bias particularly if an article covers several topics. Both came to agreement that the topic that was heavily discussed in each article was declared the *Specific Topic* and the final list appears on Table 3. For clarity, Table 6: Broad and Specific Topics is shown:

Table 6: Most frequent is highlighted and in bold letters

CATEGORIES	DETAILS	SELECTED ARTICLES															TOTAL
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
		Ehret et al.	Gravel et al.	Haag & Marsden	Lim et al.	Yorgancioglu &	Christensen et al.	Christensen et al.	Maus	Maus	Rahimi et al.	Lerner	Lutnaes	Nielsen & Braenne	Pacione	Pangrazio	Wright et al.	
Broad Topics	Affect and participatory culture	1																1
	Maker spaces literacy		1															1
	Empathy			1														1
	Interaction design				1													1
	Design education					1												1
	Designerly stance towards inquiry						1	1										2
	Design literacy for sustainability								1	1				1				3
	Visual-spatial skill and Design literacy											1						1
	Design literacy for primary level												1					1
	Design literacy for secondary level						**1**	**1**	**1**	**1**	**1**		**1**	**1**				**7**
	Design literacy for all														1	1		2
	Design literacy as production of digital artifacts															1		1
	Design literacy for educators																1	1
Specific Topics	Booktubers	1																1
	STEM literacies in maker spaces		1															1
	Use of persona in user-centred design			1														1
	Somaesthetics				1													1
	Critique and its role in design literacy					1												1
	Design literacy tool (DeL)						1											1
	Fablab							1										1
	Case Keramikk								1									1
	Case Sveip (bentwood box)									1								1
	Interest-driven literacy										1							1
	Visual-spatial ability and problem-solving skill											1						1
	Responsible design literacy												1					1
	Design for longer-lasting products													1				1
	Design literacy for non-designers														1			1
	Critical digital literacy to digital design literacy															1		1
	Design immersion program for educators																1	1

Research Methodology

Focused group interview was the most popular method used from the selected journal articles. It was closely followed by case studies. The rest of the articles featured narrative review in combination with review of literature for articles discussing conceptual frameworks.

Sector

The most researched sector was the secondary education sector with seven articles. Two journal articles from this sector combined secondary students with their educators while another journal article combined secondary and primary students for study. The higher education sector was the least researched sector with 5 journal articles. This emergent gap will be discussed further in the *Discussion* section.

Emergent Themes

Two major themes of design literacy in literature were uncovered from the SQLR. The two themes emerged from: a) sum of tabulated results, b) reviewing the broad and specific topics and, c) author's conclusion after analysing the results. These two emergent themes of design literacy relate to the findings under the *Disciplinary Field:*

1. 1) Design literacy for *making things in the physical world* is representative of secondary education sector of general education
2. 2) Design literacy for *making meanings in the digital environment* is representative of higher education. Figure 2 shows the themes and connection:

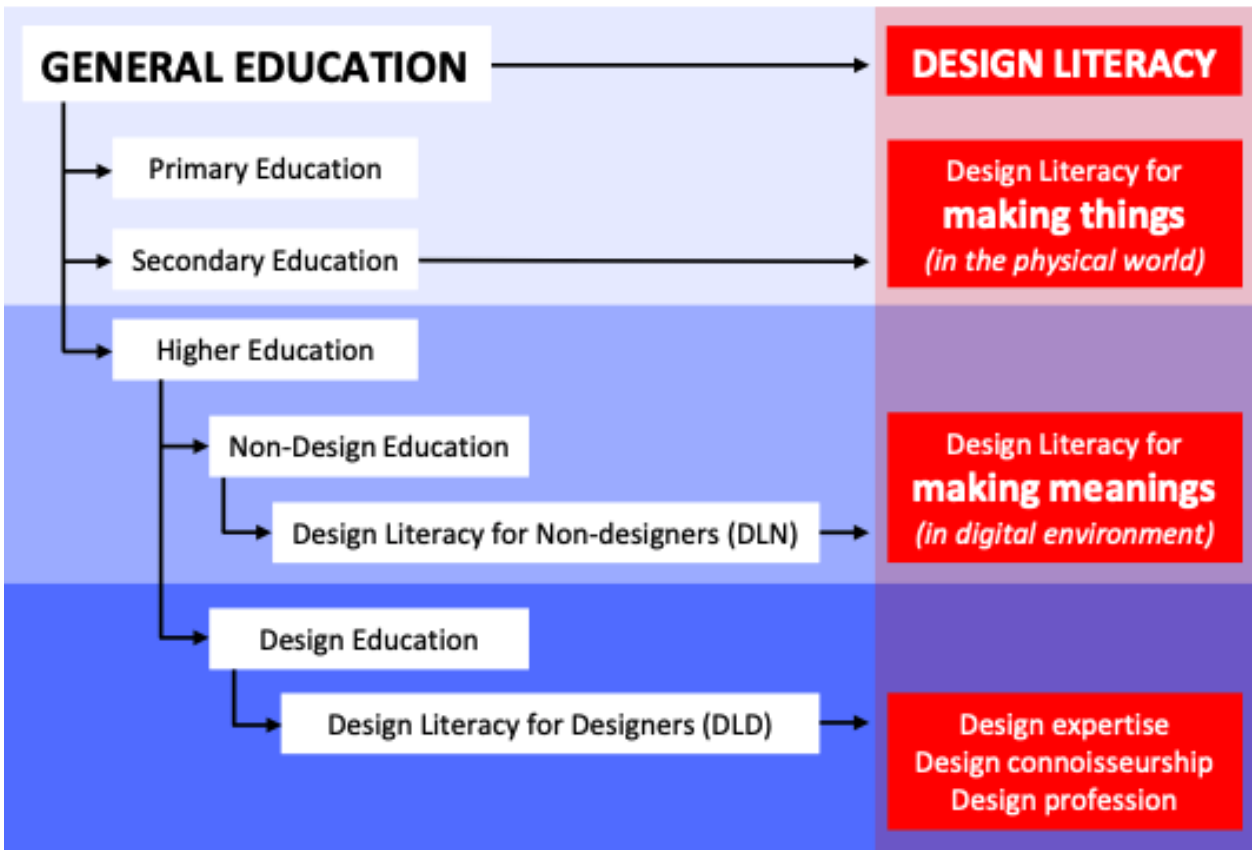

Figure 2 Design literacy primarily in Secondary Education is about making things. Design literacy in Higher Education for non-designers (DLN) is about making meanings. Design literacy for designers (DLD) is about building expertise, connoisseurship, and profession.

In addition, these emergent themes correlate with Cross'(1982) rationale of including design in general education and his conclusion that design literacy supports the development of concrete (making things) and iconic (making meanings) modes of cognition in everyone.

'Design literacy for making things in the physical world'

Nine of the 16 journal articles (56%) discussed design literacy for making things in the physical world from - designing longer-lasting products (Nielsen & Brænne, 2013), place-based design camp (Wright et al., 2018), arts and crafts for primary and secondary education (Lutnæs, 2020; Maus, 2019a, 2019b), students' stance towards inquiry to a wicked problem in a maker setting

(Christensen et al., 2016; Christensen et al., 2018), and developing design literacy among students using design critique (Yorgancıoğlu & Tunali, 2020). The journal articles cover interesting topics, however insights into the making of things in the physical world is not the focus of this SQLR.

'Design literacy for making meanings in the digital environment'

Six journal articles (38%) fall under this theme. The meagre results indicate that this theme is emerging and has a lot of potential for research. The research topics are diverse with no overlapping scope: defining the role of affect in online literacies (Ehret et al., 2018), exploring personas to foster empathy (Haag & Marsden, 2018), critique of digital design literacy as production of digital forms (Pangrazio, 2016), advocating human-centred literacy for the digital age (Pacione, 2010), and promoting interest-driven practices in a technology classroom (Baradaran Rahimi & Kim, 2018). One journal article studies the interactivity feature for interaction design that covers both the physical and digital dimension (Lim et al., 2011). The articles describe the meaning-making attributes of design literacy in higher education as visual, verbal and social articulations of non-linear information that are absent in the physical making of products. It is different from the material nature of making things and the textual nature of learning in the physical world where written or printed text is the norm.

Finally, Lerner's (2018) lone article (6%) does not cover either the *making of things* nor *meaning making* but rather discusses about how design literacy increases aesthetic growth with visual-spatial skills.

Discussion

The meagre number of journal articles (16) reviewed in this SQLR vis-a-vis the diversity of topics, field subjects, and research methods prevented direct comparison of results and generalisation of topics. Two issues raised in the *Results* section are discussed in detail: the popularity of design literacy for sustainability in secondary education, or *design literacy for making things*, and the meagre research in higher education and its implications on the theme *design literacy for making meanings*.

As a background information, an inquiry into the state of design literacy after the EDLB directive was sought. The SQLR showed that European countries had the most publication, represented by Norway (4) and Denmark (2). The remaining articles came from non-European countries led by the USA with 4 articles. These articles demonstrate the adoption of the EDLB directive #20 – "to raise design literacy awareness by fostering a culture of *design learning for all* at every level of the education system" (Thomson & Koskinen, 2012, p. 73).The SQLR revealed there were seven publications (44%) on secondary education. All the articles discuss sustainability issues with regards to the *making of things* in the physical world. The situated practice of design literacy in secondary education is "to build awareness through making" (Lutnæs, 2020, p. 13) by applying design thinking to spark innovation, civic participation and responsible citizenship in students.

On the other hand, five articles (31%) from the SQLR pertains to research in higher education. These articles demonstrate the adoption of EDLB directive #21 – "to support the development of design competencies for the 21st century by embedding the strategic role of *design across disciplines in higher education*" (Thomson & Koskinen, 2012, p. 73). This emergent gap can be

attributed to the following reasons: a) the challenge and complexity of embedding design literacy in non-design curriculum, and b) the absence of an international governing body that advocates design literacy and champion its inclusion and identity in disciplines beyond design-allied courses. The EDLB is a good precursor. Sharon Poggenpohl (2008) raises the concern in design that "other disciplines discover its methods of thinking and development and perhaps presume to poach on its intellectual and creative territory"(p. 234). An example is the adaptation of design thinking in IT software development where it is called by another name - Agile Method (Dobrigkeit & de Paula, 2019; Schneider, 2017). To close this gap, design education scholars need to take the lead in conducting research that identifies and reinforces design education's intrinsic contribution across disciplines. Design scholars have a serious stake in steering and stimulating design literacy studies across disciplines particularly in the expanding frontiers of the digital environment and the emerging knowledge economy.

The SQLR identified the emerging theme of *design literacy for making meaning* as the situated practice of design literacy in higher education. Design literacy's affinity with the digital environment is undeniable. James E. Porter (2007) describes the digital environment as the use of *technology-as-cultural-space* or *technology-as-production-space* or the place where people live and not just a medium for communication. Anne Balsamo (2009) states that Design is the *practice of techno-cultural reproduction* (p. 2), stating that the practice of Design is akin to the skills of participatory culture (Jenkins, 2009) that supports design literacy in the digital environment. Digital technology has transformed learning environments, enabling online or distance learning (Moore et al., 2011) to emerge. Ilana Snyder (2008) observes that the digital environment is where students' learning and literacy happen but is generally considered an extra-curricular space that is not reflected in most curriculum. The digital environment supported the online migration of higher education's learning experiences during the pandemic. Higher education's role in society is important. Higher education leads research and curriculum development in response to societal changes and market demands (Wright et al., 2013). It is where students learn discipline-specific skills and technical knowledge to prepare them to work in industries of their choice (Jackson, 2015). Higher education is an important platform to prepare students for employability in the knowledge economy (Choy & Delahaye, 2011; Rowe & Zegwaard, 2017). As workplaces are transformed by digital technologies, labor-intensive work associated with production of material culture is becoming obsolete. Graduates face a more complex digital workplace requiring high-level skills and tacit knowledge. They are expected to manage the wicked nature of real-world problems in knowledge-intensive industries (Kabir & Carayannis, 2013). Design literacy in higher education builds students' collaborative mindset with the skills of participatory culture and develops inquiring, empathic mindset with design thinking to help them become creative problem-solvers and changemakers with the ability to create their desirable futures.

Limitations of the Study

All research studies including SQLRs, have shortcomings and limitations. The SQLR undertaken is considered a *benchmark review* in mapping and identifying literature from purely peer-reviewed journal articles containing the keywords 'design literacy' and 'higher education'. This article is a *starting point* to initiate discourses on cross-disciplinary design literacy research in higher education. The author acknowledges that grey literature may offer rich perspective of design literacy but was not included in this SQLR because of challenges, resource limitations, or strategic considerations. First, identifying them in regular online or library search was

challenging because some were listed as 'citations' only. Second, some literatures were not available in full text, required special access, or under embargo. Third, with those that were accessed, theses/dissertations and book references require time and energy that takes away these resources from reviewing other literature. The author used stringent inclusion criteria to investigate how SQLR works. The implication of this rigorous approach may have resulted in the low turnout of journal articles for review. The search phrase used was strictly *design literacy* and omitted phrases like *design capacity*, *technological literacy*, *design thinking* or other synonymous phrases for clarity and brevity of search to seriously track the use of *design literacy* as a term and field of study. Future studies may investigate how the term *design literacy* may be interwoven or conflated with traditional concepts or fused with other terms. This article serves a starting point for contemporary and future considerations of the topic. Despite the limitations, this article's benchmark review and SQLR findings may modestly contribute to advancing the study of design literacy.

Conclusion

Design literacy is a relatively new research area. A systematic quantitative literature review (SQLR) was conducted to serve as a benchmark review to explore its potential as an essential literacy for the digital age. Design literacy develops natural abilities to solve real-world, wicked problems by supporting the development of concrete (making things) and iconic (making meanings) modes of cognition in everyone. Design literacy supports nonverbal thought and communication for the development of tacit knowledge that is essential in today's knowledge economy.

The SQLR identified 16 journal articles using clear selection criteria from 12 databases. The shortlisted articles were meagre in quantity but provided rich information to describe the emergent characteristic of design literacy in general education to inform the author's interest in higher education. There was reservation to conduct SQLR at the start of review, but the merits of this method became apparent in the end. The SQLR provided clear narrative with numbers. It was helpful in establishing baseline information on design literacy and map the breadth of literature as an emerging topic. Early career researchers may benefit from the simplicity of its process using entry-level research skills. It was useful for addressing specific questions of *who, what, where* and *when* based on specific key data search where knowledge of the research topic is minimal. SQLR is favorable to early career researchers who are novices on a topic and does not yet possess the breadth of knowledge that experts in the field profess to undertake a narrative review.

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Appendix A

Table 1: Database Search Result (Complete)

Resource	Search Terms	Search Type	Date Conducted	Initial Results	Final Results	Notes	Papers used
Google Scholar	("design literacy") AND ("higher education" OR HE OR tertiary OR " university students)	Advance search	13 December 2020	1760	Last 10 years - 1210 Peer reviewed - 22 Journal article - 22		16
ProQuest				718	Last 10 years - 361 Peer reviewed - 52 Journal article - 52	2 duplicates from Google Scholar (Baradaran, Christensen)	6
Griffith Library Database				212	Last 10 years - 137 Peer reviewed - 68 Journal article - 66	1 duplicate from Griffith (Hung),	8
SpringerLink				134	Last 10 years - 109 Peer reviewed - 18 Journal article - 18	6 duplicates from ProQuest (Atkinson, Wright, Haag, Aitken, Mosley, Christensen), 1 from Griffith (Gravel)	1
JSTOR				75	Last 10 years - 27 Peer reviewed - 24 Journal article - 17	2 duplicates from Google Scholar (Parsons, Price-Dennis), 1 from Sage (Barba)	1
Web of Science	("design literacy")			36	Last 10 years - 29 Peer reviewed - 18 Journal article - 18	1 duplicate from Google Scholar (Lerner),	2
Design and Applied Arts Index (DAAI)	("design literacy") AND ("higher education" OR HE OR tertiary OR " university students)			30	Last 10 years - 15 Peer reviewed - 12 Journal article - 12	1 duplicate from ProQuest (Lim)	2
Taylor and Francis				29	Last 10 years - 12 Peer reviewed - 12 Journal article - 12		2
SAGE				6	Last 10 years - 6 Peer reviewed - 6 Journal article - 6	1 duplicate from Griffith (Ewenstein), 1 from Scopus (Barba)	1
Scopus				3	Last 10 years - 3 Peer reviewed - 1 Journal article - 1	1 duplicate from Google Scholar (Melles)	1
ERIC				1	Last 10 years - 1 Peer reviewed - 1 Journal article - 1	1 duplicate from ProQuest (Marciano)	1
Bloomsbury Design Library		Basic search		0	Last 10 years - 0 Peer reviewed - 0 Journal article - 0		0
Total				Journal articles - **225**			**41**