CT-Nord TeaEdu
Scaffolding Computational Thinking –
Enhancing Nordic Teacher Education

Module 2

Taxonomy of CT resources

Introduction

The concept of computational thinking and the CT movement in computing/informatics education have not emerged uncontested. The conceptual foundations of the term are problematic, and have been criticized from a range of perspectives. Many critics have pointed out a disconnect between the CT movement and the long history of computing as a discipline. Initial definitions of the term were sweeping and rhetorical; providing little guidance as to what might or might not be included. There is also a nearly complete disconnect between computing education research, computational thinking and informatics in schools research communities leading to confusion about what should be included in curriculum and how it would be taught. There is also a strong tendency to consider CT as something new and different \cite{guzdial15,voogt15,tedre16}.

Whether CT ideas are really unique, or whether they are to some degree common to many fields of science, technology, and mathematics, has been debated \cite{nardelli19,grover18,barr11,pears19}. There is also disagreement on whether CT education should be concerned with high-level concepts and skills, programming, design, or machine concepts \cite{mannila14,armoni16,kafai16,lye14}. Pears (forthcoming) argues that the tacit basis of CT is the imperative programming paradigm, with a concrete focus on third generation imperative language syntax and flow of control (ref, Pears_FIE_2021).
This influence of implicit focus has limited the scope of the discourse on CT, limiting it to a very small part of the conceptual foundations of the computing disciplines (ref:cc2020 report).

Background

Computational Thinking (CT) has been the subject of intense discussion, since the term was coined by Wing in 2006 (ref). In his essay ``Remaining Trouble Spots with Computational Thinking,'' Peter J.\ Denning \cite{denning17} argued that education researchers and teachers struggle especially much with three questions: ``What is computational thinking?,'' ``How can it be assessed?,'' and ``Is it good for everyone?.'' He then continued to address each of the questions, expanding on the historical roots of computational thinking, research on skill development, and the transfer hypothesis in education. This study contributes an extension to Denning's ``trouble spots'' and identifies eight more potentially troublesome ideas and trends in CT and the CT movement that warrant substantial further research and discussion. Those trouble spots are concerned with CT imagery, the abstraction levels at which CT is envisaged to operate, and the kinds of skills involved in CT. Some of these trouble spots are more common across the multitude of different CT initiatives than others, but all of them are regularly found in some form or another.

Rapid Review of Literature

Process

The literature review focuses on studies done in Swedish primary, upper secondary, pre-school, teacher training or similar context where teaching and learning of computational thinking is central.

Computational thinking is not explicitly mentioned in the Swedish curriculum. *Programming* on the other hand is a core concept for teaching and learning computational thinking. In research concerning Swedish education, there is an interest in computational thinking as an important knowledge for children and youth.

Figure 1 shows the design process of the literature review, which presents as a four-step process. In step 1, the choice was made to conduct a systematic literature review focusing on Sweden and the Swedish curriculum. A fairly narrow focus provides the opportunity to develop a model that is possible to scale up for a larger amount of information.

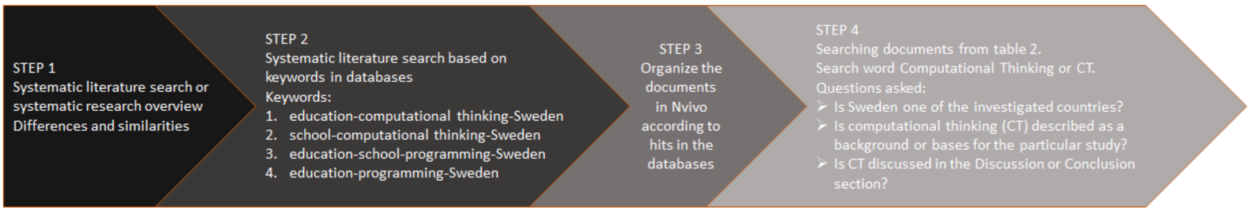


Figure 1 shows the design process.

Result of step 2
The databases ERIC, Scopus and Web of Science Core Collection are selected as search tools. The selection is based on searches and filtering on the KTH library web site and communication with librarians and fellow researchers.

The following combination of keywords is used to get a relevant selection of articles, papers and abstracts: education-Computational-Thinking-Sweden; school-Computational-Thinking-Sweden; education-programming-Sweden; education-school-programming-Sweden. The keywords *education* and *school* give slightly different search results; the combination of the two words narrows the search result.

The procedure for searching and selecting relevant documents is shown in Figure 2. Irrelevant material is sorted out, such as studies that do not concern computational thinking or education. Studies on higher education have also been removed, with the exception of research concerning computational thinking and teacher education. After screening and removing duplicates, 46 documents remain for further review.

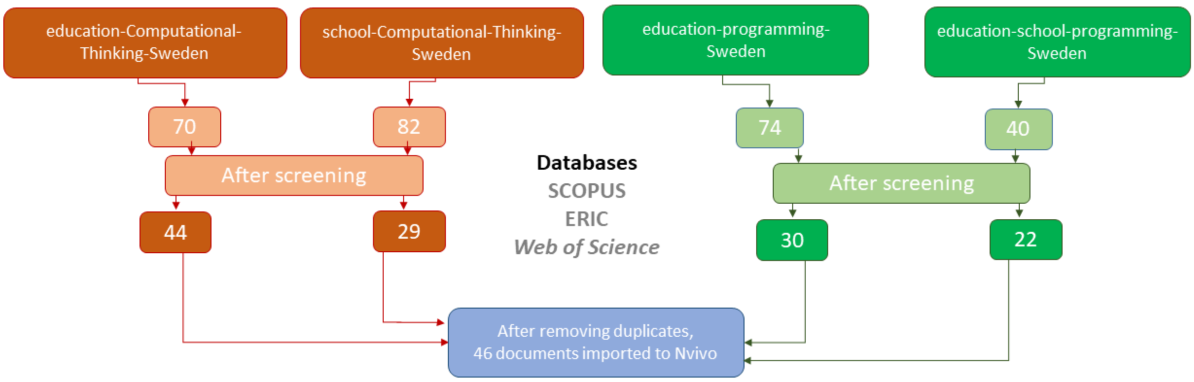


Figure 2 shows the search and selection procedure for documents used in the literature review.

Result of step 3
All documents are imported into software NVivo and Excel for qualitative data analysis.

Databases and keywords are converted into codes. These can be identified by word combinations. Databases as follows: ERIC (E), Scopus (S), Web of Science Core Collection (W). Key word combinations described earlier: education-Computational-Thinking-Sweden (eCTS); school-Computational-Thinking-Sweden (sCTS); education-school-programming-Sweden (espS); education programming Sweden (epS).

Web of Science Core Collection and the key word combination eCTS (education-Computational-Thinking-Sweden) generated the most hits (Table 1, WeCTS).

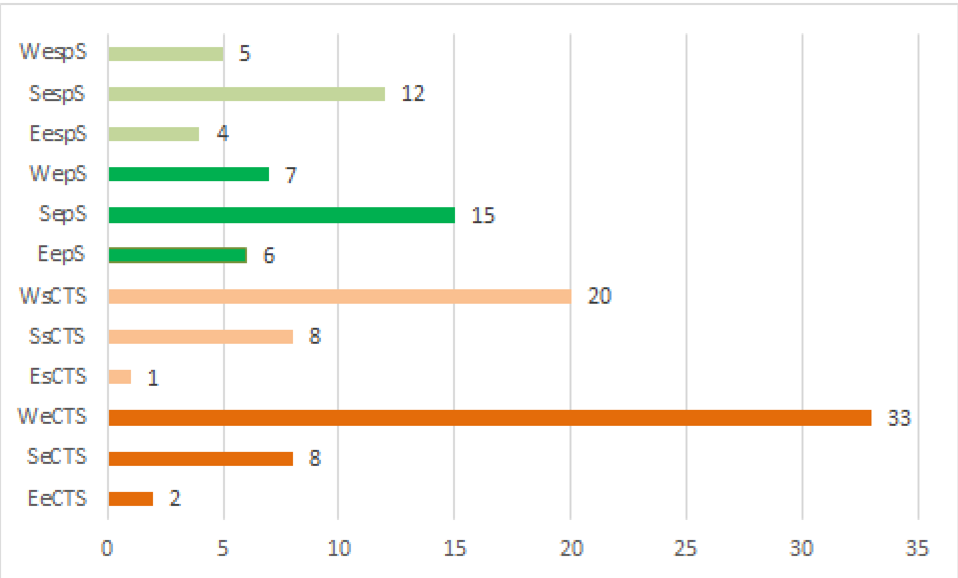
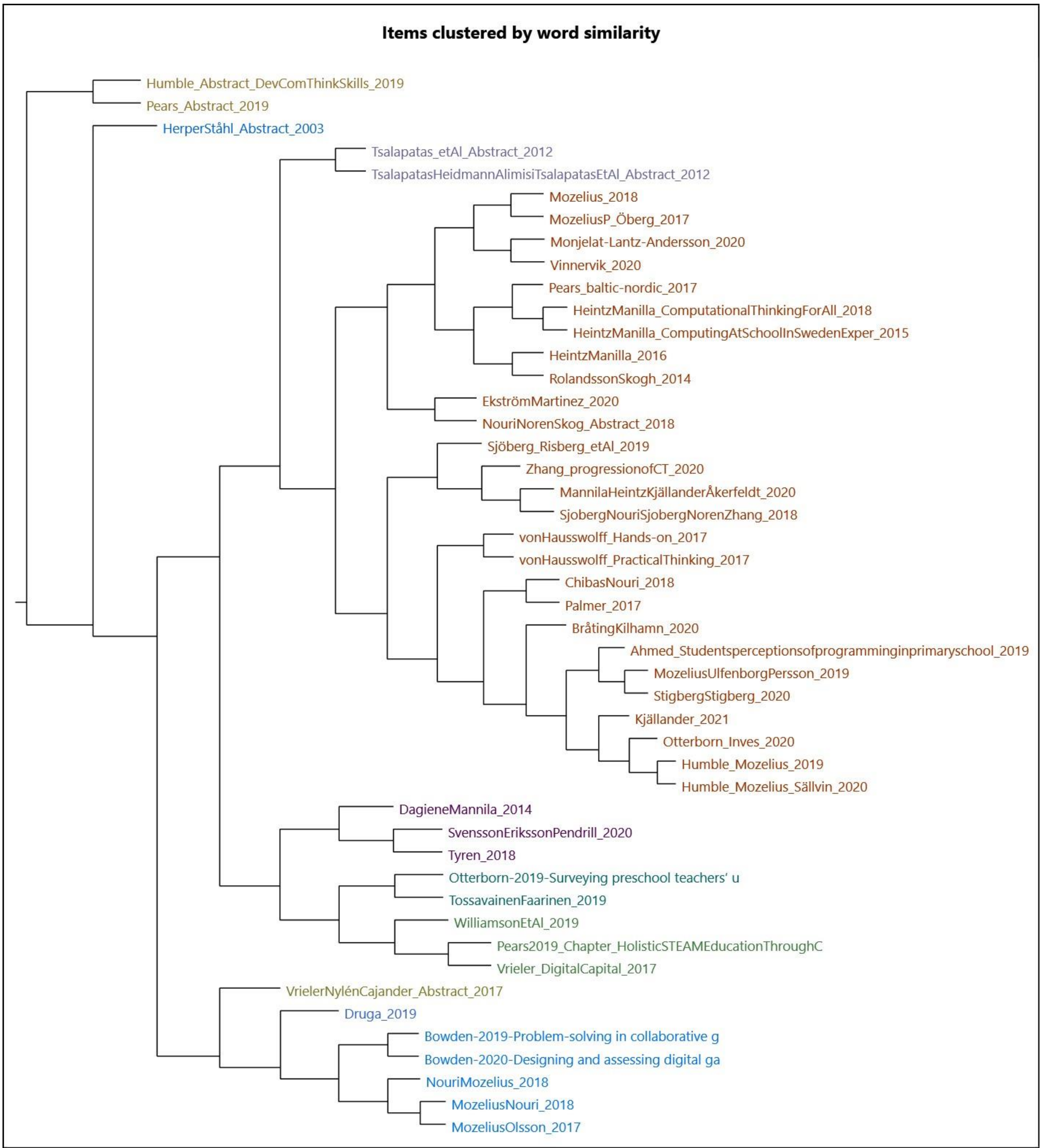


Table 1. Hits in databases based on keywords.

Result of step 4



Defining CT - central concept map

Operational definitions of CT have been attempted in the literature, but, further analysis of the literature and terminology employed reveals that most definitions cover only a small part of the disciplinary area of computing. An attempt to provide a more complete overview of the computationally relevant aspects of the computing disciplines has not previously been attempted to our knowledge. Figure \ref{figure:CT} is an attempt to present a more complete picture of the overall area of computing, with potential relevance for CT content and conceptual development.

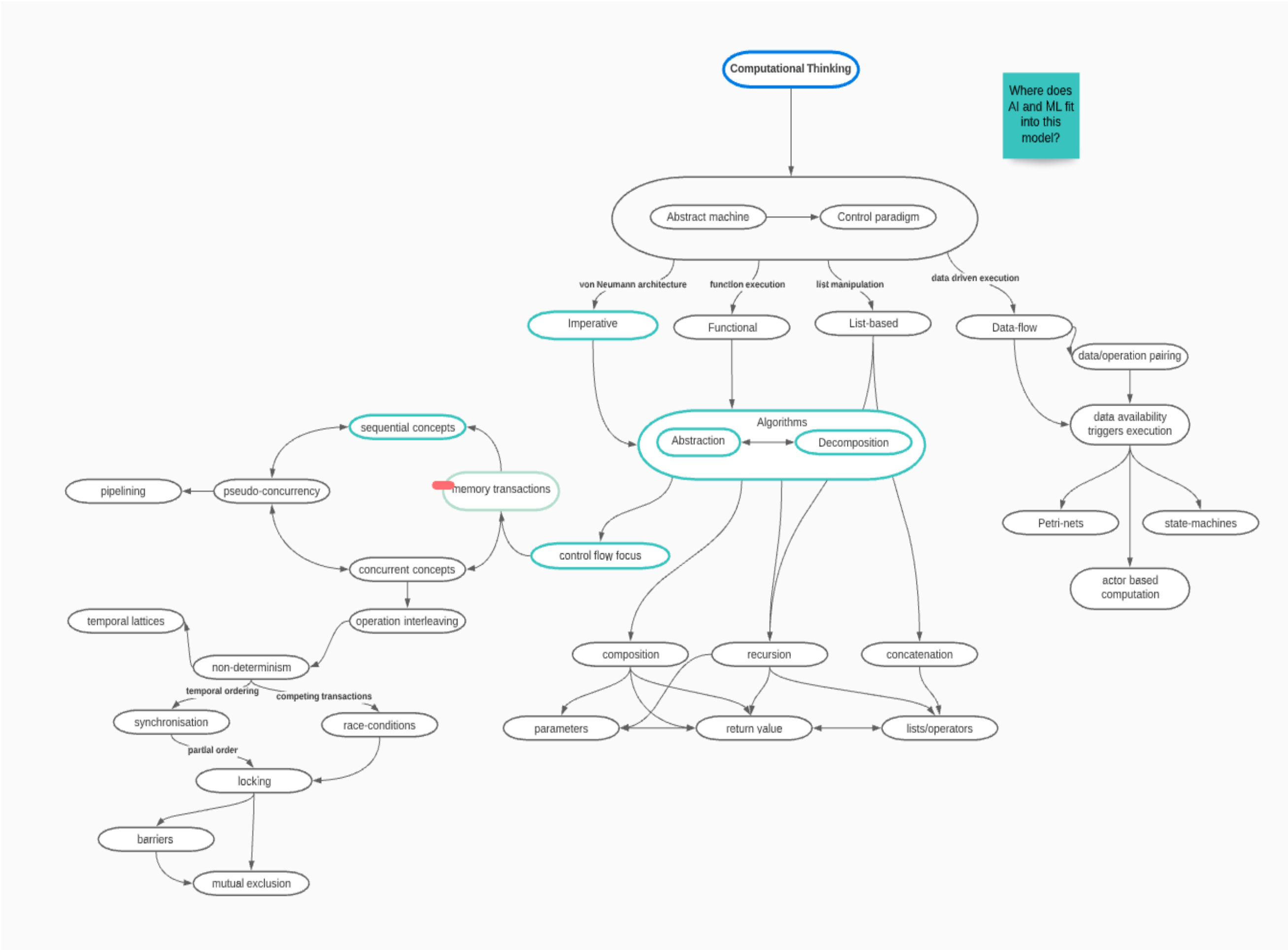


Figure: Computational Thinking Conceptual Domain

Mapping to Curriculum

The curriculum is the teacher's support in teaching and learning and defines the character and content of the subjects. In this section, the current state of computational thinking in the Swedish curriculum is analyzed.

In 2015, the government commissioned the Swedish National Agency for Education to submit proposals for content in the national digitaliseringsstrateg. As a result, the curriculum for compulsory school was revised and digital competence was added.

The revised curriculum applies from 2018 and describes digital competence as follows: a) att förstå digitaliseringens påverkan på samhället, b) att kunna använda och förstå digitala verktyg och medier, c) att ha ett kritiskt och ansvarsfullt förhållningssätt, och slutligen d) att kunna lösa problem och omsätta idéer i handling. Direkt citat, s. 6 (Sverige. Skolverket (2019). Digital kompetens i förskola, skola och vuxenutbildning [Elektronisk resurs]. Stockholm: Skolverket.

The comparable term to computational thinking in Swedish is “Datalogiskt tänkande” (DT). The curriculum does not explicitly mention DT. Instead, in the curriculum word combinations with "digital" and "program" are means to fulfill the goals when it comes to digital competence.

Programming has been in the curriculum since 2018 and is a way of acquiring digital competence, especially prominent is programming in the subjects mathematics and technology.

Mapping process, searching for signs of computational thinking, part 1

A PDF version of the curriculum is searched as a first overview mapping and Excell is used for documentation. This initial mapping showed that word combinations with digital occurs in all subjects except English, Home and consumer studies and Sign language for the hearing.

Programming occurs in three subjects, Mathematics, Civics and Technology.

In NVivo is the initial analysis verified by word counting and coding. Table x shows the school subjects and the number of hits where word combinations of “digital” (Digital*) and “program” (Program*) occur.

	A : Digital*	B : Program*
1 : Bild	4	0
2 : Biologi	7	0
3 : Fritidshemmet	3	0
4 : Fysik	6	0
5 : Förskoleklass	2	0
6 : Geografi	3	0
7 : Historia	3	0
8 : Idrott och hälsa	3	0
9 : Kemi	6	0
10 : Matematik	13	8
11 : Moderna språk	15	0
12 : Modersmål	10	0
13 : Musik	9	0
14 : Religionskunskap	3	0
15 : Samhällskunskap	8	1
16 : Samiska	4	0
17 : Slöjd	5	0
18 : Svenska	19	0
19 : Svenska som andra språk	17	0
20 : Teknik	13	4
21 : Övergripande mål och riktlinjer	8	0

* Ändelser eller kombinationer, tex digitala verktyg, programmering.

Table x shows school subjects and the occurrence of word combinations “digital” (Digital*) and “program” (Program*)

	A : Matematik	B : Samhällskunskap	C : Teknik
1 : digital bearbetning	0	0	0
2 : digital bildbehandling	0	0	0
3 : digital form	0	0	0
4 : digital teknik	4	0	1
5 : digitala hjälpmedel	0	0	0
6 : digitala kompetens	0	0	0
7 : digitala medier	0	5	0
8 : digitala miljöer	0	1	1
9 : digitala modeller	0	0	9
10 : digitala skisser och ritningar	0	0	1
11 : digitala utvecklingen	0	0	0
12 : digitala verktyg	9	2	1
13 : digitalisering	0	0	0
14 : Programmering	8	1	4

Table xx

Table xx shows the three subjects mapped to programming, Mathematics, Civics and Technology. It also shows the word combinations with "digital".

"Digital tools" occur in all three subjects, most in mathematics. In mathematics and technology, there are references to "digital technology". In technology, "digital models" are most prominent but "digital sketches and drawings" and "digital environments" also occur. "digital environments" is also found in Civics as well as references to "digital media".

Mapping process, searching for signs of computational thinking, part 2

Mathematics

Civics

Technology

Discussion and Recommendations for Teaching

Conclusion

Resources

Bebras lodge
Unplugged website
AI and ML resources

Appendix

Table 1.												
Documents, authors and publishing year						*Hits in databases*			1			
	EeCTS	EepS	EespS	EsCTS	SeCTS	SepS	SespS	SsCTS	WeCTS	WepS	WespS	WsCTS
1 : Ahmed, G., Nouri, J., Norén, E., & Zhang, L. (2019)	0	0	0	0	1	1	1	1	1	0	0	1
2 : Bowden, H. M. (2019)	0	0	0	0	0	0	0	0	1	0	0	1
3 : Bowden, H. M., & Aarsand, P. (2020)	0	0	0	0	0	0	0	0	1	0	0	0
4 : Brating, K., & Kilhamn, C. (2020)	0	0	0	0	0	0	0	0	1	0	0	1
5 : Chibas, A., Nouri, J., Noren, E., Zhang, L., & Sjoberg, C. (2018)	0	0	0	0	0	0	0	0	1	0	0	1
6 : Druga, S., Vu, S. T., Likhith, E., & Qiu, T. (2019)	0	0	0	0	0	1	1	0	0	0	0	0
7 : Ekstrom, S., & Martinez, A. F. (2020)	0	0	0	0	0	0	0	0	1	0	0	1
8 : Heintz, F., & Mannila, L. (2018)	0	0	0	0	1	1	1	1	1	0	0	0
9 : Heintz, F., Mannila, L., & Farnqvist, T. (2016)	0	0	0	0	1	1	1	1	1	0	0	1
10 : Heintz, F., Mannila, L., Nygårds, K., Parnes, P., & Regnell, B. (2015)	0	0	0	0	1	0	0	1	1	0	0	1
11 : Herper, H., & Ståhl, I. (2003)	0	0	0	0	0	1	1	0	0	0	0	0
12 : Humble, N. (2019)	0	0	0	0	0	0	0	0	1	0	0	0
13 : Humble, N., Mozelius, P., & Sallvin, L. (2019)	0	0	0	0	0	1	0	0	1	1	0	0
14 : Humble, N., Mozelius, P., & Sallvin, L. (2020)	0	0	0	0	0	0	0	0	1	0	0	1
15 : Izu, C., Mirolo, C., Settle, A., Mannila, L., & Stupuriene, G. (2017)	0	0	0	0	0	0	0	0	1	0	0	1
16 : Kjallander, S., Mannila, L., Akerfeldt, A., & Heintz, F. (2021)	0	0	0	0	0	0	0	0	1	0	0	1
17 : Monjelat, N., & Lantz-Andersson, A. (2020)	0	0	0	0	0	0	0	0	1	0	0	0
18 : Mozelius, P. (2018)	0	0	0	0	0	0	0	0	1	0	1	1
19 : Mozelius, P., & Oberg, L. M. (2017)	0	0	0	0	0	0	0	0	1	0	0	1
20 : Mozelius, P., & Olsson, M. (2017)	0	0	0	0	0	0	0	0	1	0	0	0
21 : Mozelius, P., Ulfenborg, M., & Persson, N. (2019)	0	0	0	0	0	0	0	0	0	1	1	0
22 : Nouri, J., & Mozelius, P. (2018)	0	0	0	0	0	0	0	0	1	0	0	0
23 : Nouri, J., Noren, E., & Skog, K. (2018)	0	0	0	0	0	0	0	0	0	1	1	0
	EeCTS	EepS	EespS	EsCTS	SeCTS	SepS	SespS	SsCTS	WeCTS	WepS	WespS	WsCTS
24 : Otterborn, A., Schönborn, K. J., & Hultén, M. (2020)	1	1	0	0	1	1	0	0	1	1	0	0
25 : Otterborn, A., Schönborn, K., & Hultén, M. (2019)	0	1	0	0	0	1	1	0	0	0	0	0
26 : Palmer, H. (2017)	0	0	0	0	0	0	0	0	1	0	0	0
27 : Pears, A. N. (2019)	0	0	0	0	0	0	0	0	1	0	0	0
28 : Pears, A., Barendsen, E., Dagien, V., Dolgopolovas, V., & Jasut, E. (2019)	0	0	0	0	0	0	0	0	1	0	0	1
29 : Pears, A., Dagiene, V., & Jasute, E. (2017)	0	0	0	0	1	0	0	1	1	0	0	1
30 : Rolandsson, L., & Skogh, I. B. (2014)	0	1	1	0	0	1	1	0	0	0	0	0
31 : Sjoberg, C., Nouri, J., Sjoberg, R., Noren, E., & Zhang, L. (2018)	0	0	0	0	0	0	0	0	1	0	0	1
32 : Sjoberg, C., Risberg, T., Nouri, J., Noren, E., & Zhang, L. (2019)	0	0	0	0	0	0	0	0	1	1	1	1
33 : Stigberg, H., & Stigberg, S. (2020) 2	1	1	1	1	1	1	1	1	1	1	1	1
34 : Svensson, K., Eriksson, U., & Pendrill, A. M. (2020)	0	0	0	0	0	0	0	0	1	0	0	0
35 : Tossavainen, T., & Faarinen, E. C. (2019)	0	1	1	0	0	1	1	0	0	0	0	0
36 : Tsalapatas, H., Heidmann, O., Alimisi, R., Florou, C., & Houstis, E. (2012)	0	0	0	0	0	0	0	0	1	0	0	1
37 : Tsalapatas, H., Heidmann, O., Alimisi, R., Tsalapatas, S., Florou, C., & Houstis, E. (2012)	0	0	0	0	0	0	0	0	0	1	0	0
38 : Tyrén, M., Carlborg, N., Heath, C., & Eriksson, E. (2018)	0	0	0	0	0	0	0	1	0	0	0	0
39 : Williamson, B., Bergviken Rensfeldt, A., Player-Koro, C., & Selwyn, N. (2019)	0	1	1	0	0	1	1	0	0	0	0	0
40 : Vinnervik, P. (2020)	0	0	0	0	0	0	0	0	1	0	0	1
41 : Von Hausswolff, K. (2017)	0	0	0	0	0	1	1	0	0	0	0	0
42 : von Hausswolff, K. (2017)	0	0	0	0	0	0	0	0	1	0	0	0
43 : Vrieler, T. (2017)	0	0	0	0	0	0	0	0	1	0	0	0
44 : Vrieler, T., Nylén, A., & Cajander, Å. (2017)	0	0	0	0	0	1	0	0	0	0	0	0
45 : Zhang, L. C., & Nouri, J. (2019)	0	0	0	0	0	0	0	0	1	0	0	1
46 : Zhang, L. C., Nouri, J., & Rolandsson, L. (2020)	0	0	0	0	1	1	1	1	0	0	0	0

Databases and keywords are identified by word combinations at the top of the columns to the right. shows documents and hits in the databases. shows each document and hits in the databases, a hit is marked with 1. Web of Science Core Collection and the key word combination eCTS (education-Computational-Thinking-Sweden) generated the most hits (1). One of all documents generated hits in all databases and on all keywords (2).