Swedish Undergraduate Information Systems Curricula: A Comparative Study

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Abstract

The authors do a comprehensive comparison of the Swedish Information Systems undergraduate programs in order to on the one hand get a better understanding of how the Swedish curriculum compares to the Australian and US counter parts and on the other hand also get an understanding of where the IS field has changed over time. This change is debated to get a clearer view of what courses should be core in a post 2020 curriculum. The study points to some significant overlaps where Foundations of Information Systems, Data and Information Management, and Systems Analysis and Design are important for both Swedish, Australian, and US undergraduate IS programs. The study also shows differences in focus in the different countries curriculum, where the Swedish programs have a clear focus towards enterprise architecture and application development in comparison to both the Australian and US counterparts.

Keywords: Curriculum Design, IS Education, IS Curriculum Classification, Information Systems Curricula, Information System Education.

1. Introduction

Information Systems (IS) and the use of IS could be argued to be one of the most important, if not the most important, emblematic and ubiquitous technologies in our modern society. This implies that teaching and understanding of how IS interacts with business and society as a whole should be of central importance to all governments. Even though academic programs catering to IS knowledge started to appear in the late 1960's, the major professional body, i.e. the Association of Information Systems (AIS), was not established until the mid1990's[1].

This indicates that the field is still young and one representation of this can be seen in the fact that we find academic programs centred around IS in many different faculties as well as different departments within the faculties. IS permeates everything in our everyday life, and the way we interact with different systems and technology increases every day and in that capacity it should be apparent that an up to date and functioning IS curriculum is of vital importance. The latest guideline for IS curriculum [21] is now 10 years old and it is uncertain if it still represents the sought after curriculum for universities around the

[1] https://history.aisnet.org/images/Docs/Association_for_Information_Systems.pdf

world. A few studies have been done in order to verify to what degree academic programs adhere to the IS 2010 guidelines, most notably [14] did a comprehensive study on the Australian undergraduate Information System curricula as a comparative study towards other studies done in a similar fashion. This study was envisioned to be a comparative study of [14] set in a Swedish context.

2. IS Curricula

Over the decades it has been argued that Information Systems is not a mature field and that it even exhibits some uncertainty about its own identity e.g. [17]. The IS field in itself is built on rapidly changing technologies, which would inherently suggest that the field as such must change with the evolving technologies. [20, p. 731] argues that: "the professional context in which our graduates do their work has changed considerably over the past decade, and this change should be reflected in the curriculum."

One strong factor behind this article and the mayor revision of the IS curricula that became IS2010 was because there had been a rapid decline in the study of IS as a field among students. In hindsight it could be argued that some of this decline could be attributed to the dot come bubble bursting, but this does not take away from the fact that the IS curriculum needs constant change due to the very nature of the subject being studied. This has led us to present times where we find criticism against the lack of programming in the IS 2010 Curriculum Guidelines, e.g. [1, 2, 15]. Even a program specifically designed after the IS2010 Curriculum Guidelines [4] still put quite much emphasis om programming and program design.

Furthermore, there has also been discussion on the flattened curriculum structure e.g. [13] who argue that students who work from IS 2002 will have a greater depth of knowledge in specific areas compared to students who have gone through a program which models its curriculum after IS 2010. One change from the IS 2002 curriculum compared to the IS 2010 curriculum is the inclusion of Enterprise Architecture (EA) as a core module. EA is often considered to be one of the better ways to align and understand how information systems align with business needs[16].

Even though we have these discussions, or criticism, it is interesting to note that, during his 2016 study of the IS curricula in US AACSB-accredited colleges, Yang by using his current as well as 2012 work on IS curricula, concludes that IS has become a mature discipline from the perspective of academic institutions [22]. Could it be that IS as a field needs to always have an ongoing discussion, but that we now have reached some form of maturity so this doesn't imply that we are in a crisis, or that we don't have an identity but rather that it is inherent in the subject matter that we need to constantly reinvent ourselves and the field in which we are working?

3. Method

The term Information Systems (IS) is typically translated into the terms "systemvetenskap" or "informatik" in Sweden. In order to find the undergraduate IS education programs given in Sweden, we therefore searched the web using search strings for "systemvetenskap&program" and "informatik&program." This search gave us a first list of potential undergraduate IS programs. Since we know most of the other universities and IS education programs in Sweden, we first checked the generated list to see that it contained these. We then checked the intake statistics for undergraduate education programs[2] for the fall of 2018 published on the web by the Swedish Council for Higher Education to confirm further the list of institutions and programs. Through this method we found 19 programs that are either explicitly called an IS program (including Swedish derivatives of the IS term) or, by checking the curricula with expected learning outcomes, program layout and structure, etc. we deemed to be IS programs.

The kinds of program we were interested in are three years long education programs

[2] https://www.uhr.se/studier-och-antagning/Antagningsstatistik/soka-antagningsstatistik/

comprising 180 HEC (Higher Education Credits) according to the Bologna accord for higher education in Europe. We excluded programs that were designed as 90 HEC IS and 90 HEC of non-IS content and learning, since we do not consider such programs to be pure IS programs (the Y shape of programs in the study by [14]) in a Swedish context. An example of such a program could be 90 HEC IS and 90 HEC BA forming an IT-BA program. Other types of program that were not considered in this study, are programs that instead of a BA focus have a more technical and computer science kind of focus, which we also deemed to be outside of the scope of this study.

Each curriculum was downloaded and stored locally. Following that every syllabus for the courses offered in the programs according to the curricula were downloaded and stored locally. The curricula, syllabi and the programs and course websites were then checked for consistency.

In order to hold the data collected for the study, we built a relational database in MySql Server 8.0 to persist the data in a structured model that made it possible to do different kinds of queries and analysis. This database was loaded with the facts about the institutions (university, faculty and department), programs, courses, and modules found in the downloaded documents. We again ran checks against the websites and education portals of the institutions giving the IS education programs to confirm that the curricula match the information published on the web. When it differed, we chose the information published online as this would more likely be up to date.

We retrieved the fourteen IS 2010 modules (courses) from [21, p. 35] and entered them into the database. Seven of the modules are considered as core and have assigned codes (IS2010.1 to IS2010.7)[3] while the remaining seven are example elective modules and thus lack codes. To identify uniquely all the modules, they were stored with a numerical identification index of 1 to 14.

3.1. Coding and Analysis

The typical size in HEC of a course in a Swedish IS education program is 7.5, meaning five full-time study weeks. However, some programs have courses that are more than 7.5 HECs and thus may comprise distinct modules with name and amount of HECs specified in the syllabi. In such a case, it was treated as an identifiable module and entered into the database. If there were distinctively identifiable course exams clearly indicating course modules, they were also treated as identifiable modules and entered into the database.

The courses investigated are worth between 1 HEC and 30 HECs, where 30 HEC is equivalent to a full semester of full time studies. 257 (73.8 %) of the courses are worth 7.5 HECs, 63 (18.1%) are worth 15.0 HECs, 18 (5.2%) are worth 30.0 HECs, 5 (1.4%) are worth 6.0 HECs, 3 (0.9%) are worth between 1.0 and 4.0 HECs, and 2 (0.6%) are worth between 12.0 and 14.0 HECs.

A further analysis of bigger courses (> 7.5 HECs) that were not designed with distinct modules (55 courses) revealed that 30 were degree project courses, placement courses (real-world projects), project work courses, and research methodology courses, without rationales for separate modules. This leaves 25 courses that could have associations with more than one IS 2010 module. A review of these courses' syllabi resulted in 11 courses (3.2% of all the courses) that in e.g. the expected learning outcomes clearly showed that they involved more than one IS 2010 module, for instance IS Project Management, Systems Analysis and Design, and Application Development. If it was possible to infer identifiable modules through e.g. name of exams and if it was possible to infer or guess the size of these in HEC we divided the course into distinct modules. Otherwise, we coded the course as one IS 2010 module based on the main topics and learning outcomes of the course.

In the database, courses without modules were treated as modules in themselves. Courses that had some form of modules were assigned modules identified by the course code plus an index (course code plus "-n", e.g. TIG015-1) and were associated with these

[3] We discovered that [1] are inconsistent and that IS2010.4 is IS Project Management on page 35 but is IT Infrastructure on page 45. In our study, we have used the labels from page 35.

modules in the database. In total, this procedure resulted in 348 distinct courses and 392 distinct modules. Hence, we inferred 44 modules from the syllabi. Each such module was then analysed by scrutinizing the module name, expected learning outcomes, content, etc. This was compared with the IS 2010 modules from [21] and the modules were either coded with 1 to 14, or, if we did not see a distinct match, with 'null'. The results of the coding were stored in the database.

In order to improve the validity of the analysis the comparison between the identified modules in our data and the IS 2010 modules was first done by the first author of the paper. This list was then checked by the second author and the differences in coding was discussed to form a joint opinion and one code. This procedure resulted in 287 modules associated with IS 2010 modules (coded 1 to 14) and 105 modules not associated with IS 2010 modules (coded 'null').

4. Findings

In Sweden, there are 36 government funded higher education institutions. Through the procedure described above we concluded that 17 of these offer 19 undergraduate IS programs that had an intake during 2018. In the text, tables, and figures we use the ISO3366-1 alpha-2 two-letter country codes for Sweden (SE), Australia (AU), USA (US), and UK (GB).

4.1. Program Placement in Academic Division

Different to the discussion in [14], the type of academic division where the Swedish programs are placed is less straight forward. In [14] two types of divisions account for 28 out of 32 programs, namely Science, Engineering & Technology (SET) and Business divisions. The typical organization of higher education in Swedish universities and university colleges is Institution -> Faculty -> Department. There are also Business Schools that are faculties (Lund University) or departments (Örebro University). The Department of Computer and Systems Sciences (DSV) of Stockholm University is part of the Faculty of Social Sciences. At the University of Gothenburg, the department, Applied Information Technology, involved in the education program is part of the IT Faculty, which also has the department of Computer Science and Information Technology. Most of the 19 programs involve more than one faculty and at most three faculties.

Table 1. The Main Type of Division of Program Placement

Main Academic Division Type	Count
Social Science	3
Social Science and Technology	6
Technology	4
Business	4
	17

A further analysis revealed that the academic divisions where the majority of the courses of the programs were given were distributed as in Table 1. Historically, business administration has been part of Social Science divisions and hence it is fair to say that the IS undergraduate education programs in this study largely reside under the Social Science umbrella of subjects and divisions. Under this umbrella, four departments could be classified as Business.

4.2. Subject Areas Compared to the IS 2010 Curriculum Guidelines

In Table 2 the IS 2010 Curriculum Guidelines modules that we determined to be covered by the education programs are listed and the coverage calculated in percent. We added a column showing the matching figures from Table 1 in [14] rounded to one decimal.

As can be seen, two IS 2010 modules are covered by all the investigated programs (Foundations of Information Systems and Application Development) while five of the IS 2010 core modules are covered by at least close to 60% percent of the programs in Sweden

(SE). In the Australian study (AU) by [14] four core IS 2010 modules are covered by at least close to 70% of the programs. In Table 1 in [14] only IS 2010 modules covered by at least five programs are listed, which might explain the "n.a." that we needed to insert in the AU column in Table 2.

Table 2. IS 2010 Modules Required in Swedish (SE) and Australian (AU) Undergraduate IS Programs (modules with assigned IS 2010 codes are core modules)

IS 2010 Code	IS 2010 Subject Category	SE % (n=19)	AU % (n=33) [14]
IS2010.1	Foundations of Information Systems	100.0%	75.7%
	Application Development	100.0%	18.2%
IS2010.2	Data and Information Management	94.7%	94.0%
IS2010.6	Systems Analysis and Design	89.5%	97.0%
	Introduction to Human-Computer Interaction	78.9%	27.3%
IS2010.4	IS Project Management	68.4%	69.7%
IS2010.3	Enterprise Architecture	57.9%	n.a.
	Enterprise Systems	47.4%	18.2%
	Business Process Management	42.1%	21.2%
IS2010.7	IS Strategy, Management and Acquisition	31.6%	30.3%
	IT Security and Risk Management	31.6%	15.2%
IS2010.5	IT Infrastructure	26.3%	45.5%
	IS Innovation and New Technologies	15.8%	n.a.
	IT Audit and Controls	0,0%	n.a.

There are both similarities and differences between the Swedish and Australian figures that might reflect different traditions and foci. As can be seen in Table 3, four core IS 2010 modules differ less than 10 percentage between Sweden and Australia and thus seem to form a set of common core subjects between these countries' undergraduate IS education programs.

Table 3. Similarities between SE and AU programs with Reference to IS 2010 Modules

IS 2010 Code	IS 2010 Subject Category	SE % (n=19)	AU % (n=33) [14]
IS2010.2	Data and Information Management	94.7%	94.0%
IS2010.6	Systems Analysis and Design	89.5%	97.0%
IS2010.4	IS Project Management	68.4%	69.7%
IS2010.7	IS Strategy, Management and Acquisition	31.6%	30.3%

The differences are shown in Table 4, where eight subject categories differ more than 10 percentage (including the "n.a." values). Substantial differences are evident in the Application Development subject category, where 100% of the Swedish programs cover this subject while only 18.2% of the programs in the Australian study do that.

However, in Table 1 in [14] there is a non-IS 2010 subject category called Fundamentals of Programming that 78.8% of the programs in the Australian study covers. This subject could be subsumed under the IS 2010 Application Development module. If we then compare to Table 2 we still find a relatively big difference of more than 20 percentage. Hence, one clear difference between Sweden and Australia concerning undergraduate IS education programs is that programming fundamentals is a required subject in Sweden but not in Australia.

Table 4. Major Differences between SE and AU Program with Reference to IS 2010 Modules

IS 2010 Code	IS 2010 Subject Category	SE % (n=19)	AU % (n=33) [14]
IS2010.1	Foundations of Information Systems	100.0%	75.7%
	Application Development	100.0%	18.2%
	Introduction to Human-Computer Interaction	78.9%	27.3%
IS2010.3	Enterprise Architecture	57.9%	n.a.
	Enterprise Systems	47.4%	18.2%
	Business Process Management	42.1%	21.2%
	IT Security and Risk Management	31.6%	15.2%
	IS Innovation and New Technologies	15.8%	n.a.

Other important differences relate to Enterprise Architecture, Enterprise Systems, Business Process Management, and IT Infrastructure. The three former subjects are quite important in the Swedish programs since at least 40% cover them and especially Enterprise Architecture, which is close to 60%. This might have to do with coding, since the ACM/AIS IS 2010 Curriculum Guidelines [21] is a bit imprecise (necessarily so) and also more technical aspects of architecture could be coded as Enterprise Architecture, for instance a more technical level of Information Architecture or Software Oriented Architecture (SOA) with implementations using e.g. Web Services. Enterprise Architecture however did not make it to Table 1 in [14] and according to the authors, Enterprise Architecture was a distinct unit in only two Australian programs.

Finally, and what surprised us, was the low coverage of IT Infrastructure and IT Audit and Controls in Sweden with only 26.3% and 0% respectively of the programs devoting space to these subjects. Very few modules in the 19 programs concern themselves with computer and systems architecture. Rather, the fact that just over a fourth had this subject in the program has to do with the communication network part of IT Infrastructure. The IS 2010 subject category of IT Audit and Controls is totally absent in the Swedish 19 programs and also did not make it to Table 1 in [14].

4.3. A Comparison between Swedish, Australian, US, and GB studies

In Table 5 this study, the Australian study [Table 1 in ref. 14] and the two US studies [22, p. 262] (US_1), [Table 1 in ref. 9] (US_3) referenced in [14] and a third US study [Table 5 in ref. 3] (US_2) are compared. The rows with medium blue background (darker grey in black and white) represent less than 20% difference (e.g., 80% differs 20% from 100%) between the Swedish values and the average. Rows marked with a light red background (lighter grey in black and white) represents bigger than 20% difference between Swedish values and the average.

Based on the table, it is evident that three core IS 2010 Modules (IS2010.2, IS2010.6, and IS2010.1) are very important to all the studied programs and are common to IS undergraduate programs in Sweden, Australia and USA. We also see quite similar values for IS2010.7 (except for US_3). Big differences exist for IS2010.5, which is quite important in the three US studies, medium important in the Australian study, and less important in the Swedish study. Another big difference is IS2010.4, which is quite important in both the Swedish and Australian studies, but less so in the three US studies. The Introduction to Human-Computer Interaction IS 2010 subject category seems to be very important in Sweden with 78.9% of the studied programs covering this kind of module compared to 27.3% in the Australian study [14] and 0.0% in the US_1 study [22]. Also for IS2010.3, there is a big difference between Sweden and the other countries. At the same time is it evident in Table 5 that IS undergraduate programs in Sweden and Australia have more in common than they have with IS undergraduate programs in USA.

The study by [14] also references a similar UK study [17]. The major difference in the UK study is that they use the IS 2002 Model Curriculum and Guidelines [7] and the QAA SBSC for classification of modules and not the IS 2010 Curriculum Guidelines [21]. Hence, it is not possible to add that study to Table 5. However, the authors of the UK study

[17, p. 402] conclude that "Traditional IS subjects such as systems analysis, IS theory, IS practice, programming, databases and project management were confirmed as the most popular across the 228 IS courses identified." It therefore feels safe to conclude that the UK study in [11] corresponds well with the SE findings inTable 5.

Table 5. Comparison of IS 2010 Module Coverage between SE, AU and three US studies (US_2 and US_3 did not provide any figures for non-core IS 2010 modules).

IS 2010 Code	Subject Category	SE % (n=19)	AU % (n=33)	US_1 % (n=234)	US_2 % (n=127)	US_3 % (n=394)	Avg.
IS2010.2	Data and Information Management	94.7%	94.0%	94.0%	97.0%	87.3%	93,4%
IS2010.6	Systems Analysis and Design	89.5%	97.0%	90.0%	84.0%	79.7%	88,0%
IS2010.1	Foundations of Information Systems	100.0%	75.7%	84.0%	87.0%	62.7%	81,9%
	Application Development	100.0%	18.2%	84.0%	n.a.	n.a.	67,4%
IS2010.5	IT Infrastructure	26.3%	45.5%	68.0%	70.0%	66.2%	55,2%
IS2010.4	IS Project Management	68.4%	69.7%	28.0%	38.0%	32.2%	47,3%
	Introduction to Human-Computer Interaction	78.9%	27.3%	0.0%	n.a.	n.a.	35,4%
IS2010.7	IS Strategy, Management and Acquisition	31.6%	30.3%	30.0%	29.0%	15.5%	27,3%
	Enterprise Systems	47.4%	18.2%	9.0%	n.a.	n.a.	24,9%
	Business Process Management	42.1%	21.2%	6.0%	n.a.	n.a.	23,1%
IS2010.3	Enterprise Architecture	57.9%	n.a.	3.0%	17.0%	13.5%	22,9%
	IT Security and Risk Management	31.6%	15.2%	9.0%	n.a.	n.a.	18,6%
	IS Innovation and New Technologies	15.8%	n.a.	5.0%	n.a.	n.a.	10,4%
	IT Audit and Controls	0.0%	n.a.	0.0%	n.a.	n.a.	0,0%

4.4. Programs Placement in Academic Division and IS 2010 Module Coverage

According to [14] the placement of the program within a SET (Science, Engineering and Technology) or a Business academic division had an impact on the size of the IS core in their study. The SET-based programs had on average 12.3 core IS units per program while Business-based programs on average had nine core IS units per program. The differences between SET-based and Business-based programs were, according to the authors, not so marked for the non-core IS units.

One program in our study covers all IS 2010 core modules and is placed in a Technology academic division. Two programs cover six IS 2010 core modules with one program residing in a Social Science and Technology division and the other in a Business division. At the other end of this scale we find four Social Science and Technology placed

programs and two Technology placed programs covering four IS 2010 core modules and two Business placed programs covering three IS 2010 core modules.

The coverage of the non-core IS 2010 modules show a similar non-systematic distribution. Four programs cover five non-core IS 2010 modules. Three of these are Business type and one is Social Science and Technology type. At the other end of this scale are a Business placed program covering three non-core IS 2010 modules, two Technology and one Social Science placed programs covering two non-core IS 2010 modules, and two Social Science and Technology placed programs covering one non-core IS 2010 module. When it comes to all IS 2010 modules we also see no real differences as shown in Table 6.

Table 6. Program Placement According to Academic Division Type

IS 2010 Modules	Academic Division Types
5	Social Science and Technology
6	Technology and Business
7	Social Science and Technology
8	Social Science and Technology
9	Technology
10	Social Science, Business and Technology

4.5. Swedish IS Modules Compared to IS 2010 Modules

Leaving the comparison between Sweden, Australia and US programs to concentrate on the details of the Swedish programs investigated in this study, we see in Table 7 a clear relation to Table 2. In our analysis, the number of modules in the programs that we coded as associated with IS 2010 modules is consistent with the IS 2010 modules coverage by the programs. Two IS 2010 Subject Categories count for close to a fourth of the modules in our study, showing that these two represent real core modules and subjects in the studied programs. In Table 2 these two subject categories are also associated with all the 19 programs.

Table 7. IS 2010 Module Coverage in Swedish Undergraduate IS Programs (Core Modules Are Assigned with IS 2010 Codes)

IS 2010 Code	IS 2010 Subject Category	Count	%
IS2010.1	Foundations of Information Systems	66	23,0%
	Application Development	65	22,6%
IS2010.6	Systems Analysis and Design	33	11,5%
	Introduction to Human-Computer Interaction	23	8,0%
IS2010.2	Data and Information Management	21	7,3%
IS2010.4	IS Project Management	19	6,6%
IS2010.3	Enterprise Architecture	17	5,9%
	Enterprise Systems	10	3,5%
IS2010.5	IT Infrastructure	8	2,8%
IS2010.7	IS Strategy, Management and Acquisition	8	2,8%
	Business Process Management	7	2,4%
	IT Security and Risk Management	6	2,1%
	IS Innovation and New Technologies	4	1,4%
		287	**100,0%**

In Figure 1 the coverage of IS 2010 core and non-core modules in the Swedish programs is shown. Minimum three and maximum seven IS 2010 core modules are associated with the programs, with an average of 4.7. For the IS 2010 non-core modules the corresponding figures are between one and five with an average of 3.2.

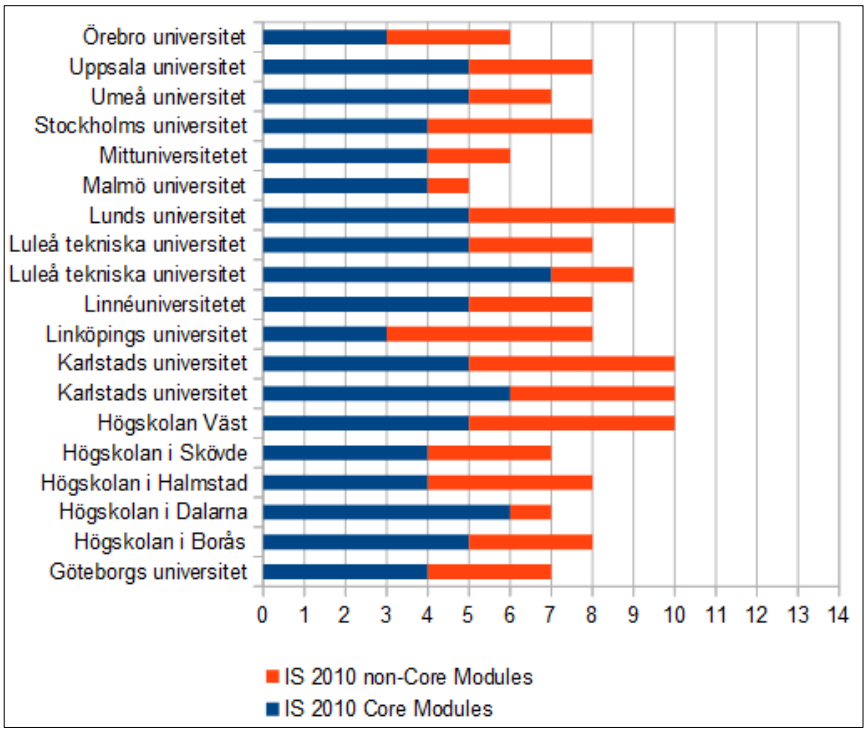

Figure 1. IS 2010 Module Coverage by Swedish IS Undergraduate Education Programs

There are a number of modules in the studied programs that we could not match with any IS 2010 module. The inferred subject categories of these are shown in Table 8.

Table 8. Subject Categories for Modules Not Associated with Any IS 2010 Modules In Swedish Undergraduate IS Programs

Subject Category	Count	Percent
Business Administration	25	6.4%
Research Methods	21	5.4%
Degree Project/Bachelor's thesis[4]	20	5.1%
Placement/Real-world project	8	2.0%
Computer Science	7	1.8%
Mathematics	6	1.5%
Geographical Information Systems	4	1.0%
IT Service Management	2	0.5%
IT Law	2	0.5%
Cognitive Science	1	0.3%
Neuroscience	1	0.3%
Semiotics	1	0.3%
Language	1	0.3%
Learning Portfolio	1	0.3%
	100	**25.51%**

Compulsory for undergraduate education programs in Sweden is they must include a degree project and in the case of three years long programs (180 HEC) for a general degree (not vocational programs like nursing programs) this means a Bachelor's thesis. Since the IS programs in this study have their traditional base in Social Science and is of a general degree type, the degree project is a Bachelor's thesis. Even though the traditions stem from

[4] We did not find any syllabus for the Bachelor's thesis course at Stockholm University

Social Science is the degree normally a BSc. All the programs in this study have a thesis module and therefore several programs have distinct modules for research methods.

Table 8 shows the subject categories for the modules that we did not associate with any IS 2010 modules. As evident, research methods and degree project (BSc thesis) are in the top three non-IS 2010 module list together with modules in the Business Administration (BA) subject category. Under this subject category, we find typical BA modules of accounting, marketing, organization and leadership, management accounting, etc. Seven programs offer the students a possibility of some kind of placement or real-world project. The subject category of Computer Science has modules of logics and data structures and algorithms. The Mathematics subject category comprises statistics, logics and discrete mathematics.

5. Conclusions

This study has mainly compared IS undergraduate programs in Sweden with a similar study done in Australia [14]. When analyzed through the lens of IS 2010 Curriculum Guidelines [21] we find that four core IS 2010 subject categories differ less than ten percentages in coverage between Swedish and Australian IS undergraduate programs: Data and Information Management, Systems Analysis and Design, IS Project Management, and IS Strategy, Management and Acquisition. Four IS 2010 core and non-core subject categories coverage that show big differences between Sweden (from relatively high to high coverage) and Australia (relatively low coverage) are: Foundations of Information Systems, Application Development, Introduction to Human-Computer Interaction, and Enterprise Architecture. The strong importance of academic division type and placement of the programs found in the Australian study is not found in this study. There seems to be no systematic variation in IS 2010 module coverage attributed to academic division type program placement in this study.

We also compared to three US studies of IS 2010 Curriculum Guidelines module coverage and find that Foundations of Information Systems, Data and Information Management, and Systems Analysis and Design are important for both Swedish, Australian, and US undergraduate IS programs. Big differences between on the one hand Sweden and Australia and on the other hand USA are IT Infrastructure which has more than 65% coverage in the US, circa 45% coverage in Australia, and just circa 26% coverage in Sweden. Another big difference is IS Project Management, which has close to 70% coverage in both Sweden and Australia, but under 40% in the US studies. Therefore, there seems to be a common core in Swedish, Australian, and US undergraduate IS programs. However, there are also important differences in e.g. the high importance of IT Infrastructure and low importance of IS Project Management in the US programs. In this respect, Swedish and Australian IS undergraduate programs have more in common than what they have with similar programs in USA.

We see that Application Development (including programming fundamentals) is still very important in all the Swedish programs, reflecting the discussions in [1, 2, 15] about the omission of this from the core of IS 2010 Curriculum Guidelines modules. One of the differences between the IS 2002 Model Curriculum [5] and the IS 2010 Curriculum Guidelines [21] is the inclusion of Enterprise Architecture as core and the problems of this as discussed in e.g. [16]. The Swedish programs have, totally different to the programs in the referenced Australian and US studies, implemented this change to a high degree with close to 60% coverage in programs and counting for close to 6% of all modules in the programs. This is not as much as e.g. Foundations of Information Systems, but far more than the closest coverage value of 17% in one of the US studies.

It is interesting to note that [19] has, at least partially, incorporated a few of the subjects we could not associate with with any IS 2010 modules as discussed under section 4.5. Noteworthy are Ethics and Sustainability, which are both core parts of the research methods module as well as the actual Bachelor thesis. Furthermore, Strategy and Governance could fall under IT Law. In [18] Topi discusses how the modern curricula is shaped by competencies, as also described in [19], where the knowledge, skills and human

characteristics become important guideposts. This is something that we would refer to as falling under learning portfolio, cognitive science as well as real world projects.

In the IS 2010 Curriculum Guidelines a core module is Enterprise Architecture, which Table 5 shows to be more important in Sweden than in both Australia and US. Interestingly, in the MSIS 2016 global competency model for graduate degree programs in information systems [19] Enterprise Architecture (EA) is an IS an important competence area with a minimum expected competence level of at least novice. Hence, EA seems to be quite important to the curriculum and competency models authors in IS for both undergraduate and graduate level, as well as to Swedish undergraduate curriculum designers.

We have not studied graduate IS programs in Sweden and have no information about the presence of EA in those programs. The undergraduate programs in Sweden are targeted on a Swedish context and are normally tought in Swedish. The development of what was to become IS in Sweden was early on focused on application of computing in business, processes and workflows, historically marked by the difference between Börje Langefors's datalogical and infological interests in 1966 [10], his idea of using computer systems to steer and control companies [11], and the development of higher education in the area [12]. We would say that in Sweden the kinds of issues that EA addresses were already from the beginning important. EA therefore, despite its machine-like engineering view on organizations evident in e.g the Zachman EA framework [e.g. 6, 23] as opposed to the more prevalent systems and socio-technical Swedish view rooted in the Scandinavian School [e.g. 5, 8], fits well in our tradition.

As a final reflection upon the value of IS 2010 and similar guidelines, we find they have a value in construing and aligning IS as concept and education in various parts of the world while still giving headroom for national and/or historical differences. Without them, the field would probably be much more diverse and conceptually confusing, making it hard to compare edcudation and curriculm design, not the least important learning outcomes. Therefore, our view is that the work is important and need to reflect changes in IS: Increased digitization, world shaping Digital Transformation and Automation with AI and Decisioning, IoT and Data Analytics, Social Media, etc. As we probably all experience, the pace is ever faster and there is hardly any part or aspect of society that is not affected and now also cognitive tasks in workflows are automated. Hence, IS has become one of the most powerful concepts for change and education in this area is thus central, making modernization of guidelines such as IS 2010 highly important.

6. Future work

It would be interesting to extend this kind of study to other European countries to see if European undergraduate IS programs are similar to each other and how they compare to Australian and US counterparts. Is there e.g. a European and/or Nordic IS "style"? A second interest would be to compare curriculum designs in Sweden with IS/IT job listings. We have a database that has been collecting such job advertisements published by The Swedish Public Employment Service since April 2018 and, at the time of writing this paper, holding 32 000 advertisements. Analyzing that would give us an employer perspective that could be compared to the collected undergraduate IS curricula. Furthermore, potential employers could be e.g. interviewed to see the relation between job advertisements, interview data, and curriculum data.

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