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Students' competence as eHealth and eWelfare service developers based on the International Medical Informatics Association IMIA's curriculum structure and design thinking

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Abstract

Multidisciplinary cooperation is required to develop digital health and welfare services. The aim of this article is to determine the eHealth and eWelfare service design competences that multidisciplinary students need to be able to develop digital services in health and social care. A secondary aim is to develop a measurement tool based on the International Medical Informatics Association (IMIA) curriculm for future assessment of such competences.

Based on basic descriptive statistics results show that most students felt they have good skills in e-communication, basic IT, literature retrieval and research methods; some students, however, reported that they lack these basic skills. It is crucial that instructors be aware of student variations so that they can support the learning of the basics and further the biomedical and health informatics (BMHI) and design thinking (DT) competences.

Principal components analysis (PCA) was used to determine the principal components (PC) from measured responses to BMHI and DT sections. Data were collected from 64 students. The components were explored and compared to constructs used to design the original measurement tool. A twenty-component structure showed the simplest solution and explained (80%, 68%, 73%) of variances in BMHI and 83% DT competences, respectively, in the measurement tool, each part of which was analysed by PCA. The PC can be the core areas in different professions taking part in developing eHealth and eWelfare.

The parts of measurement tools relied on item reliability and content validity testing. This study provided a base for further measurement tool revision and theoretical testing.

Keywords: competence, informatics, health services, eHealth, social work, multidisciplinary communication

Introduction

Digital health and social care services play key roles in improving care and increasing patients' levels of engagement in their own care. To develop digital services, there needs to be worldwide changes to coordinate quality health services with universal access [1] as well as strong guidelines from national policy makers [2]. Professional associations need to consider the need for multidisciplinary development work and support professionals to take part in it [3,4]. To achieve effective development and implementation, the customer-centric service culture in health care requires a human-centred design approach for co-creation of innovation [5].

In the near future, 90% of jobs will require digital skills. At the same time, nearly half (47%) of the population of the European Union (EU) does not have adequate digital skills. The EU Commission supports efforts to enhance citizens' digital skills and qualifications [6]. Since 1995, the European Computer Driving License (ECDL) has provided a worldwide format for information communication technology (ICT) skills and general knowledge to all professionals at different educational levels [7]. The biomedical and health informatics (BMHI) standardized curriculum for health and IT professionals developed by the International Medical Informatics Association (IMIA) is known worldwide [8-10]. The curricula of Information Technology (IT) engineers include informatics [11] and nursing informatics has been part of nursing curricula for many years [12-16]. Moreover, it is proposed that social science programmes include informatics in their curricula [17]. However, research shows that there is still a need to develop nursing informatics education and competences [18]. There are many ways to change education so that it becomes more multidisciplinary e.g. interprofessional workshops can be provided for healthcare students and teachers [19]. Bachelor degree students are willing to work together in multidisciplinary groups, but educators need to coordinate such programmes [20]. It is challenging to develop multidisciplinary teams and discussion is needed about roles and the need to accept plurality in order to meet the aim and respond to the needs of patients [21].

In the health informatics discipline, there have been multidisciplinary discussions about the suitability of the IT industry's Skills Framework for the Information Age (SFIA). During the process, IMIA's BMHI curriculum was mapped to SFIA. [22] For empowered and creative cooperation in the development of digital services, a common language is required [23]. Developing digital services to a single digital market [6] needs large cooperation, when developing competences [23] and for lifelong learning [24].

The European Qualifications Framework (EQF) defined by the EU is the general framework for vocational qualifications. The bachelor level in college level 5 describes knowledge as 'comprehensive, specialized, factual and theoretical knowledge within a field of work or study and an awareness of the boundaries of that knowledge'. Universities of Applied Sciences (UAS) bachelor degrees are on level 6, requiring advanced knowledge within a field of work or study involving critical understanding of theories and principles. The perspective interface between different fields is added in level 7. EQF defines knowledge, skills and competences related to all degrees [25] and the directive describes minimum competences [26]. In this study, a competence is understood as a combination of knowledge and skills.

Purpose and aims

The purpose of this article is to describe students' knowledge, skills and competence in eHealth and eWelfare service design before their participation in courses meant to develop digital health and social care services. The aim of the present study is to evaluate what types of eHealth and eWelfare service design competences multidisciplinary students need to be able to develop digital services in health and social care. An additional aim is to develop a measurement tool based on the International Medical Informatics Association (IMIA) curriculm to assess these competences in the future. A multidisciplinary study module was compiled in the international development project called Developer of Digital Health and Welfare (DeDiWe). The research questions are as follows:

1. How did the students assess their biomedical and health informatics knowledge, skills and competences before the courses?

2. How did the students assess their skills and competences in developing and designing digital services before the courses?

3. What kind of biomedical and health informatics and design thinking knowledge, skills and competences do multidisciplinary students need to be able to develop digital services in health and social care?

Material and methods

Survey instrument

The purposeful questionnaire used in this study was based on the IMIA´s recommendations for curriculum content [8-10] for EQF levels 5 and 6 [25] and described the user's IT levels in relation to the IMIA curriculum [8-10]. The questionnaire was cross-mapped with ECDL [7] and IMIA [8-10] contents. The questionnaire consisted of three parts: Background (14 scale variables), Biomedical and Health Informatics (BMHI; 72 scale variables) and Design Thinking Competences (DTC;10 scale variables). The questionnaire also contained open-ended questions: four on background and two on the DTC parts.

Background variables describe the participants' demographics, such as country, age, study programme and study path, study credits received before obtaining their bachelor's degree and study credits obtained after receiving their bachelor's degree. The IMIA's content-based recommendations for knowledge levels and professional skills in BMHI is spread among four domains. In the present study, we used three domains—BMHI core knowledge and skills; medicine, health and biosciences and health-system organization; and informatics or computer science, mathematics and biometry [8-10] which were formulated to the fields of variables as general knowledge and skills, knowledge and understanding, skills and competence. We also added the social care perspective [17] to the BMHI variables [8-10]. The questionnaire also contained questions about informatics not related to health and social care. The last part of the questionnaire included competences for design thinking (DT) [27] to describe the part of the questionnaire related to the service-design process. There were a total of 82 questions (Table 1) and a 5-point Likert scale was used. The open-ended questions are not reported in this paper.

Data collection and analysis

Students (N=82) were recruited from European partner schools in Finland (n=42), Latvia (n=20) and Estonia (20). Data were collected using an e-questionnaire administered to students who had signed up for the course developed in the project called 'Developer of Digital Health and Welfare Service (DeDiWe)'.

Participation was voluntary and the responses were anonymized in the report. The e-questionnaire was distributed to all participating students through the eLearning platform used for the study unit in Autumn 2016.

Data were transferred from the e-questionnaire (E-lomake) to an Excel spreadsheet. Prior to statistical analysis, the data were cleaned to check for outliers and missing values; there were no missing values. Data were analysed using IBM SPSS Statistic Data Editor Software 23.0 licensors 1989, 2015 (IBM Corporation, USA). Basic descriptive statistics were used for statistical analysis (parameters, percentages and arithmetic means). The distribution of variables was analysed by comparing Cronbach's alpha values between different parts of the questionnaire and significant values [28]. These values are shown in Table 2.

Table 1. Questionnaire structure.

Parts of Questionnaire	Total	BMHI Core Knowledge and Skills	Medicine, Health and Biosci-ences and Health-system Organization	Informatics/ Computer Science, Mathe-matics and Biometry	Design thinking competences
General knowledge, skills and competence (G)	14	5	0	9	0
BMHI knowledge and understanding (KU)	34	26	7	1	0
BMHI skills (S)	18	16	2	0	0
BMHI competence ©	6	0	3	3	0
Design Thinking Competences (DT)	10	0	0	0	10
Total number of questions	82	47	12	13	10

Table 2. Reliability Statistics.

Parts of the Questionnaire	Cronbach´s Alpha	Cronbach's Alpha Based on Standard-ized Items	N of Items	Sig
General knowledge, skills and competence	0 ,934	0 ,935	14	0,000
BMHI knowledge and understanding	0 ,945	0 ,945	34	0,000
BMHI skills	0 ,913	0 ,915	18	0,000
BMHI competence	0 ,800	0 ,799	6	0,000
Design Thinking Competences	0 ,955	0 ,954	10	0,000
Whole Data	0 ,964	0 ,964	82	0,000

Table 3. KMO and Bartlett´s Test.

		BMHI core	Medicine, Health and Biosciences and Health system Organi-zation	Informatics and Computer Sci-ence, Mathemat-ics, Biometry	Design Thinking
KMO Measure of Sampling Adequacy		0 ,573	0 ,830	0 ,790	0 ,912
Bartlett's Test of Sphericity	Approx. Chi-Square	2752 ,049	397 ,619	646 ,175	705 ,803
	df	1081	66	78	45
	Sig	0 ,000	0 ,000	0 ,000	0 ,000

The BMHI variable results were organized into IMIA's three domains: BMHI core knowledge and skills; medicine, health and biosciences and health-system organization; and informatics or computer science, mathematics and biometry. According to content similarity, seven groups were formed within BMHI core knowledge and skill, three groups were formed within medicine, health and biosciences and health-system organization; and four groups were formed within informatics or computer science, mathematics and biometry. In the DT section, according to content similarity and theory structure [27], four groups were formed using the DT competences content. The results and descriptive statistics are presented in Tables 5, 7, 9 and 11.

The complexity of the mean scores for the self-assessed items were reduced by principal component analysis (PCA) and components eigenvalues greater than 1. The components obtained from PCA were rotated using the Varimax criterion [28]. Subsequently, PCA was applied to all domains, which are described in Table 3. Bartlett's test of sphericity and the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy were used to justify the use of PCA based on a criterion of $p < 0{,}0001$ and 0,6 or higher. In one domain, the KMO was 0,573, but all others were greater than 0,6. The absolute value used was less than 0,30 [28].

Results

Half of the students were nurses from Finland and were under 29 years of age. There were only a few non-health and social care students. Table 4 shows the students' background information, such as country, study programme, gender, age, study path, university, bachelor's degree field, credits required to obtain bachelor's degree, study credits before, highest degree before, graduation year from last studies distribution.

Table 4. Participants' (N=64) background information.

Country	n= 64
Finland	61 %
Latvia	21 %
Estonia	19 %
Age range	
19-29	47 %
30 -39	22 %
40-49	23 %
50 and over	8 %
Gender	
Male	23 %
Female	77 %
Study Program	
Nursing	32
Physiotherapy	3
Biomedical laboratory science	3
Midwifery	3
Business Administration BBA	4
BBA - IT	3
Doctoral Assistant	7
Social and Welfare	8
Radiography	1
Enviromental Health	0
Engineering IT	0
Study Path	
Open university	15 %
Full time students	86 %
Required Credits to Bachelor	
270 ECTS	4
240 ECTS	3
210 ECTS	35
180 ECTS	2
120 ECTS	30
Study Credits Before	
<29 ECTS	25
30–59 ECTS	0
60–89 ECTS	13
90–119 ECTS	6
120–149 ECTS	18
150–179 ECTS	3
180–209 ECTS	4
210–239 ECTS	3
240–270 ECTS	1
Open university	8

The results were organized based on the BMHI's three categories; DT has its own categories.

Biomedical and health informatics core knowledge and skills

Students had the highest skills in software for personal communication (n=56 with total agree and agree), and skills in literature retrieval and research methods (n=35 with total agree and agree). Some students (n=4 with total disagree and disagree) did not have these skills. The lowest skill level was in sensor technology (n=32 with total disagree and disagree). Skills in non-health related informatics themes were lower (mean 2.8) than understanding health and social informatics themes (mean 3,4). Many students (n=29 with total disagree and disagree) assessed that they did not have sufficient skills to work with legal and regulatory issues related to IT; however, students (n=41 with total agree and agree) assessed their skills as very high in privacy and security of patient data. Results of the BMHI core knowledge and skills questions are presented in Table 5.

To reduce the variability observed in self-reports regarding biomedical and health informatics core knowledge and skills (47 variables), we conducted a PCA, which identified 12 main components explaining 80% of the results.

Following are the main components and explain the percentages of the results of the analysis: 1) Understanding health and social informatics - 31%; 2) Skills and understanding literature retrieval and research methods - 9%; 3) Knowledge and skills of ethical and security issues - 7%; 4) Understanding benefits of IT in health and social care - 7%; 5) Understanding ethical and security issues in data management - 5%; 6) Understanding and skills in health technology - 4%; 7) Skills to work with terminologies - 4%; 8) Skills to work with process modelling and reorganizationing - 3%; 9) Understanding quality of documentation - 3%; 10) Understanding information processes in health and social care - 3%; 11) Skills in personal e-communication - 2%; and 12) Skills using information processing to support practice - 2%. The saturated variables are explained components and presented in Table 6.

Table 5. Descriptive Results for Biomedical and Health Informatics Core Knowledge and Skills (N=64).

Descriptive Results for Biomedical and Health Informatics Core Knowledge and Skills					(N 64) Response rate (%)		
Content (47)	Mean	Standard Deviation	Totally Disagree 1 (n) %	Disagree 2 (n)%	Partly agree 3 (n)%	Agree 4 (n)%	Totally agree 5 (n) %
Skills in personal e communication skills							
G3 Skills in software for personal communication	4,4	0,8	(1)2 %	(0)0 %	(7)11 %	(22)34 %	(34)53 %
Skills in and understanding of literature retrieval and research methods							
G5 Understand library classification	3,7	0,8	(1)2 %	(3)5 %	(18)28 %	(33)52 %	(9)14 %
G6 Information literacy skills	3,5	0,8	(0)0 %	(7)11 %	(22)34 %	(29)45 %	(6)9 %
G7 Understanding of literature retrieval and research methods	3,5	0,8	(1)2 %	(3)5 %	(25)39 %	(30)47 %	(5)8 %
G8 Skills in literature retrieval and research methods	3,4	0,8	(0)0 %	(7)11 %	(31)48 %	(21)33 %	(5)8 %
Understanding social and health informatics							
KU1 Understanding information process in SHC	4,1	0,8	(1)2 %	(0)0 %	(12)19 %	(29)45 %	(22)34 %
KU2 Understanding benefits of IT in SHC	4,3	0,7	(0)0 %	(0)0 %	(10)16 %	(28)44 %	(26)41 %
KU3 Understanding limitations of IT in SHC	4,0	0,7	(1)2 %	(0)0 %	(11)17 %	(37)58 %	(15)23 %
KU4 Understanding systematic heath terminologies	3,4	0,8	(1)2 %	(4)6 %	(37)58 %	(15)23 %	(7)11 %
KU5 Understanding coding in systematic health terminologies	2,8	0,8	(4)6 %	(15)23 %	(33)52 %	(11)17 %	(1)2 %
KU6 Have knowledge about information systems in SHC	3,2	0,7	(0)0 %	(10)16 %	(35)55 %	(17)27 %	(2)3 %
KU7 Have knowledge about health information management	3,0	0,7	(1)2 %	(13)20 %	(36)56 %	(13)20 %	(1)2 %
KU10 Understanding patient health records	2,7	1	(8)13 %	(21)33 %	(19)30 %	(14)22 %	(2)3 %
KU12 Understanding eHealth as shared care	2,9	0,8	(1)2 %	(19)30 %	(33)52 %	(9)14 %	(2)3 %
KU13 Understanding documentation in SHC	3,3	0,9	(0)0 %	(12) 19 %	(25)39 %	(21)33 %	(6) 9 %
KU15 Understanding minimum datasets in health records	2,8	0,9	(5)8 %	(16)25 %	(35)55 %	(6)9 %	(2)3 %
KU16 Understanding principles of arcitecture of health records	2,5	0,9	(9)14 %	(20)31 %	(28)44 %	(6)9 %	(1)2 %
KU17 Understanding principles of health record apps	2,8	0,8	(4)6 %	(19)30 %	(31)49 %	(9)14 %	(1)2 %
KU25 Understanding e.g. terminologies in social and health informatics	3,1	0,9	(1)2 %	(14)22 %	(31)48 %	(14)22 %	(4)6 %
KU28 Understanding how IT support clinical decission making	3,3	0,9	(2)3 %	(9)14 %	(27)42 %	(21)33 %	(5)8 %
Skills in social and health informatics							
S1 Skills to use information processing to support health care practice	3,2	0,9	(1)2 %	(12)19 %	(30)47 %	(17)26 %	(4) 6 %
S2 Skills to use systematic health related terminologies	3,2	0,8	(1)2 %	(9)14 %	(32)50 %	(19)30 %	(3)5 %
S3 Skills to code systematic heath related terminologies	2,6	0,9	(7)11 %	(21)33 %	(25)39 %	(10)16 %	(1)2%
S4 Skills to work with information systems in health care	3,2	0,9	(2)3 %	(8) 13 %	(34)53 %	(13)20 %	(7)11 %
S5 Skills to work with health information management	3	0,9	(2)3 %	(14)22 %	(29)45 %	(17)27 %	(2)3 %
S8 Skills to work with patient health record	2,7	1,0	(9)14 %	(18)28 %	(25)39 %	(10)16 %	(2)3 %
S11 Skills to use appropriate documentation and health data management	3,4	0,9	(1)2 %	(8) 13 %	(29)45 %	(19)30 %	(7)11 %
S12 Skills to work with general applications of EH or SSR	3,2	0,9	(2)3 %	(11)17 %	(30)47 %	(17)27 %	(4)6 %
S16 Skills to document with current terminologies in SH informatics	3,1	1,0	(1)2 %	(15)23 %	(29)45 %	(12) 19 %	(7)11 %
Understanding and skills in non-health related Informatics							
KU14 Understanding data quality	3,2	0,9	(2)3 %	(10)16 %	(32)50 %	(13)20%	(7)11 %
KU18 Understanding socio-organizational and -technical issues	2,6	0,8	(5)8 %	(24)38 %	(28)42%	(6)9 %	(1)2 %

KU19 Understanding data representation and analysis	2,8	0,9	(5)8 %	(17)26 %	(32)50 %	(8) 13 %	(2)3 %
KU20 Understanding principles of data mining	2,8	1,0	(7)11 %	(15)23 %	(26)41 %	(15)24 %	(1)2 %
KU21 Understanding principles of data warehouses	2,6	0,9	(8)13 %	(19)30 %	(29)45 %	(8)13 %	(0)0 %
KU22 Understanding principles of knowledge management	2,9	0,9	(6)9 %	(13)20 %	(27)42 %	(18)28 %	(0)0 %
S13 Skills to work with workflow process, modeling and reorganization	2,9	1,0	(5)8 %	(17)27 %	(25)39 %	(13)20 %	(4)6 %
Knowledge and skills in ethical and security issues							
KU8 Have knowledge about legality and regulatory in IT	2,900 0	0,9	(3)5 %	(19)30 %	(27)42 %	(13)20 %	(2)3 %
KU9 Have knowledge about legality and regulatory in SHC IT	2,8	0,9	(4)6 %	(19)30 %	(27)42 %	(12) 19 %	(2)3 %
KU23 Understanding ethical and security issues in SHC	3,5	0,9	(2)3 %	(5)8 %	(25)39 %	(23)36 %	(9)14%
KU24 Understanding the privacy and security of patient data	4,0	1,0	(1)2 %	(3)5 %	(15)23 %	(24)38 %	(21)33 %
S6 Skills to work legal and regulatory issues related to IT	2,6	1,0	(9)14 %	(21)33 %	(23)36 %	(10)16 %	(1)2%
S7 Skills to work legal and regulatory issues in SHC related to IT	2,6	0,9	(7)11 %	(22)34 %	(26)41 %	(8) 13 %	(1)2%
S14 Skills to take account of ethical and security issues in my work	3,8	1,0	(0)0 %	(6)9 %	(21)33 %	(19)30 %	(18)28 %
S15 Skills to take account of privacy and security of patient data	3,9	1,0	(0)0 %	(7)11 %	(16)25 %	(20)31 %	(21)33 %
Understanding and skills in health technology							
KU11 Understanding sensor technology	2,8	0,9	(5)8 %	(15)23 %	(32)50 %	(10)16 %	(2)3 %
S9 Skills to work with sensor technology	2,5	1,0	(12)19 %	(20)31 %	(24)38 %	(6)9 %	(2)3 %
S10 Skills to work with eHealth	2,9	1,0	(6)9 %	(14)22 %	(25)39 %	(17)27 %	(2)3 %

G=general knowledge, skills and competence, KU=BMHI knowledge and understanding, S= BMHI skills, C= BMHI competence

Table 6. Principal Components of Biomedical and Health Informatics Core Knowledge and Skills.

Content (47)	1. Understanding health and social informatics	2.Skills and understanding the literature retrieval and research methods	3. Knowledge and skills of ethical and security issues	4. Understanding benefits of IT in health and social care	5.Understanding ethical and security issues in data management	6. Understanding and skills in health technology	7. Skills to work with terminologies	8. Skills to work process modeling and reorganizationing	9. Understanding quality of documentation	10. Understanding information process in health and social care	11.Skills in personal e-communication	12. Skills using information processing to support practice
Cumulative % of communilatity was 80%	31 %	9 %	7 %	7 %	5 %	4 %	4 %	3 %	3 %	3 %	2 %	2 %
Understanding principles of health record apps	0,811											
Understanding principles of architecture of health record	0,810											
Understanding minimum datasets in health record	0,800				-0,302							
Understanding principles of knowledge management	0,715											
Understanding principles of data ware-	0,713		-0,395		-0,334							

houses												
Have knowledge about health information management	0,708				0,303							
Understanding coding in systematic health terminologies	0,680											
Skills to work with health information management	0,657				0,354							
Understanding how IT support clinical decision making	0,648					-0,353						
Skills to work with patient health record	0,643										0,311	
Skills to code systematic heath related terminologies	0,641											
Understanding e.g. terminologies in health and social informatics	0,629											
Understanding socio-organizational and -technical issues	0,628						-0,346					
Have knowledge about legality and regulatory in health and social care IT	0,617				0,395							
Skills to use information processing to support health care practice	0,611											0,414
Skills to document with current terminologies in health and social informatics	0,601	-0,322										
Skills to work with general applications of electronic health or social service record	0,600		0,426	-0,324								
Understanding eHealth as shared care	0,598					-0,311					-0,305	
Understanding principles of data mining	0,594		-0,409		-0,429							
Have knowledge about legality and regulatory in IT	0,590				0,345		-0,387					
Skills to use systematic health related terminologies	0,588	-0,447					0,363					
Skills to work legal and regulatory issues related IT	0,562			-0,453	0,434							
Understanding systematic heath terminologies	0,557			0,421						-0,315		
Skills to work with information systems in health care	0,557			-0,341	0,364			-0,383				
Understanding data quality	0,557				-0,425				0,512			
Understanding ethical and security issues in health and social care	0,552					-0,396	-0,372					

Skills to work with sensor technology	0,548			-0,526		-0,346						
Understanding sensor technology	0,537					-0,473		0,413				
Understanding data representation and analysis	0,536	0,353										
Skills to work legal and regulatory issues in health and social care related IT	0,529			-0,363	0,458							
Have knowledge about information systems in health and social care	0,525	-0,307				0,315						
Understanding patient health record	0,504		-0,311	0,317								-0,342
Skills to work with eHealth	0,436		0,423	-0,398								
Understanding documentation in health and social care	0,416		0,336					-0,393	0,334			
Understanding of literature retrieval and research method		0,837										
Information literacy skills	0,349	0,789										
Skills to literature retrieval and research method	0,322	0,755										
Understand the library classification		0,729					0,422					
Skills to software for personal communica-tion		0,594					0,332				0,509	
Skills to use appropriate documentation and health data management	0,504		0,620									
Skills to take account of privacy and security of patient data	0,533		0,591									
Skills to take account of ethical and security issues in my work	0,502		0,525			0,352		0,306				
Understanding the benefits of IT in health and social care		0,349		0,523		0,311						
Understanding the limitations of IT in health and social care	0,343			0,460			-0,367					
Skills to work with workflow process, model-ing and reorganization	0,390	0,353		-0,426				0,413				
Understanding the privacy and security of patient data	0,349		0,398	0,363		-0,422						
Understanding information process in health and social care	0,308		0,324	0,332						-0,475		

Medicine, health and biosciences and health-system organization biometry knowledge, skills and competence

According to content similarity, four groups were formed from the medicine, health and biosciences and health-system organization content. Students had almost the same levels in all variables, however, the highest competences were found in the themes of human function and health (mean 3.6) and health and social care development (mean 3.6) and guiding clients in social and health care. Students' lowest competences were related to evidence-based clinical decision making. The results for students' medicine, health and biosciences, and health-system organization biometry knowledge, skills and competences are presented in Table 7.

To reduce the variability observed in self-reports regarding medicine, health and biosciences and health-system organization biometry knowledge and skills (with 12 variables), PCA was conducted, which allowed us to identify three components explaining 68% of the analysis results.

The following are the main components and explain the percentages of the results of the analysis: 1) Understanding patient safety initiatives - 48%; 2) Understanding quality and resource management - 11%; and 3) Understanding the basics of human functioning and health - 9%. The saturated variables are explained components and presented in Table 8.

Informatics or computer science mathematics, biometry

The results describe how students assessed their informatics or computer science mathematics, biometry knowledge, skills and competence before they took the study unit (Table 9). According to content similarity, three groups were formed. Students had the highest competence in basic IT competence (mean 3.9) and the lowest competence in the category related to decision support systems (mean 2.9). Each variable was assessed on a scale ranging from total disagree to total agree.

To reduce the variability observed in self-reports regarding informatics or computer science mathematics, biometry (13 variables), PCA was conducted, which allowed us to identify three components explaining 73% of the analysis results. The following are the main components and explain the percentages of the results of the analysis: 1) Competence to take part in change management - 47%; 2) Basic skills for IT and informatics projects - 15%; and 3) Competence to work and develop decision support systems -20%. The saturated variables are explained components and presented in Table 10.

Table 7. Descriptive Results for Medicine, Health and Biosciences and Health-System Organization (N=64).

Variables (12)	Mean	Standard Deviation	(N=64) Response rate % Totally Disagree 1 (n) %	Disagree 2 (n)%	Partly agree 3 (n)%	Agree 4 (n)%	Totally agree 5 (n) %
Human fuctioning and health							
KU26 Understanding basics of human functioning and biosciences	3,6	0,9	(2)3 %	(5)8 %	(18)31 %	(33)52 %	(6) 9 %
KU27 Understanding what constitutes health and its assessment	3,7	0,7	(0) 0 %	(2)3 %	(23) 36 %	(34)53 %	(5) 8 %
Quality and safty							
KU30 Understanding quality and resource management	3,3	0,8	(0) 0 %	(9)14 %	(33)52 %	(19)30 %	(3) 5 %
KU31 Understanding patient safety initiatives	3,5	0,9	(1) 2 %	(6) 9 %	(25) 40 %	(24)38 %	(8) 13 %
KU33 Understanding of outcome measurement	3,3	0,9	(1) 2 %	(10)16 %	(27) 42 %	(22)34 %	(4) 6 %
Competence in health and social care development							
KU32 Understanding of public health and social services	3,8	0,7	(0) 0 %	(1) 2 %	(22)34 %	(30)47 %	(11) 17 %
C1 Competence to guide clients in social and health care	3,4	0,9	(2)3 %	(3) 5 %	(31) 48 %	(22)34 %	(6) 9 %
C3 Competence to take part in the development of the eHealth	3,1	1,0	(2)3 %	(14)22 %	(26)41 %	(17)27 %	(5) 8%
Evidence-based clinical desicion making							
S17 Skills in clinical desicion making	3,1	1,1	(5)8 %	(12)19 %	(24)38 %	(16)25 %	(7) 11 %
S18 Skills to work in evidence-based practice	3,4	1,0	(2)3%	(9)14 %	(22)34 %	(23) 36 %	(8) 12 %
C2 Competence to understand clinical decissision making	3,2	0,9	(2)3 %	(12)19 %	(25)39 %	(21) 33 %	(4) 6 %
KU29 Understanding priciples of evidence-based practice	3,6	0,7	(0) 0%	(3)5 %	(25) 39 %	(29) 45 %	(7) 11 %

G=general knowledge, skills and competence, KU=BMHI knowledge and understanding, S= BMHI skills, C= BMHI competence

Table 8. Principal Components in Medicine, Health and Biosciences and Health-system Organization.

Variables (12)	1. Understanding patient safety initiatives	2. Understanding quality and resource management	3.Understanding basics of human functioning and health
Cummulative 68% of total variance	48 %	11 %	9 %
Understanding patient safety initiatives	0,790		
Skills to work in evidence-based practice	0,775		
Skills to clinical decision making	0,757	-0,356	
Understanding the priciples of evidence-based practice	0,751		
Understanding of outcome measurement	0,750	0,446	
Understanding what constitutes health and its assessment	0,741		-0,410
Competence to quide client in health and social care	0,715		
Competence to understand clinical decision making	0,714	-0,481	
Understanding of public health and social services	0,648		
Competence to take part in development of eHealth	0,559		
Understanding quality and resource management	0,471	0,680	0,456
Understanding the basics of human functioning and biosciences	0,532		-0,673

Table 9. Descriptive Results for Informatics or Computer Science Mathematics, Biometry.

			(N 64) Response %				
Variables (13)	Mean	Standard Deviation	Total Disagree 1 (n) %	Disagree 2 (n)%	Partly agree 3 (n)%	Agree 4 (n)%	Total agree 5 (n) %
Understanding and competence in project and change management							
G9 Understanding of project management	3,5	1,0	(1) 2 %	(9)14 %	(23) 36 %	(21) 33%	(10)16 %
G10 Competence to take part in project management	3,4	1,0	(2)3 %	(11) 17%	(21) 33 %	(21) 33%	(9)14 %
G11 Competence to lead project	2,8	1,1	(6) 9 %	(23) 36 %	(16) 25 %	(14)22%	(5) 8 %
G12 Understanding change management	3	1,0	(3) 5 %	(19)30 %	(19)30 %	(18)28 %	(5) 8 %
G13 Competence to take part in change management	3,1	1,1	(3) 5 %	(16) 25 %	(22)34 %	(16) 25 %	(7) 11%
G14 Competence to lead change management	2,8	1,1	(9)14 %	(18)28 %	(18)28 %	(15)23 %	(4) 6 %
Competence related to desicion support systems							
KU34 Understanding decision support methods and application to patient management	3	0,9	(2)3 %	(14)22 %	(31) 48 %	(14)22 %	(3) 5 %
C4 Competence to work with software and methods for decision support system	3	1,0	(5) 8 %	(14)22 %	(27)42 %	(14)22 %	(4) 6 %
C5 Competence to take part in development of methods for decision support and use of guidlines	3	1,0	(3) 5 %	(17)27 %	(27)42 %	(13) 20 %	(4) 6 %
Basic IT competence							
C6 Competence to communicate electronically	3,8	0,9	(1) 2 %	(3) 5 %	(19)30 %	(28)44 %	(13) 20 %
G1 Basic informatics terminology	3,8	0,9	(1) 2 %	(3) 5 %	(22)35 %	(23) 36 %	(15)23 %
G2 Skills to use software and text processing	4,5	0,7	(1) 2 %	[0] 0 %	(3)5 %	(21) 33 %	(39) 61 %
G4 Skills to spreadsheet software	3,7	1,0	(1) 2 %	(4) 6 %	(22)34 %	(21) 33 %	(16) 25%

G=general knowledge, skills and competence, KU=BMHI knowledge and understanding, S= BMHI skills, C= BMHI competence

Table 10. The Principal Components in Informatics or Computer Science Mathematics, Biometry.

Variables (12)	1. Competence to take part change management	2. Basic skills for IT and informatics projects	3. Competence to work and develope decision support systems
Cummulative 73% of total variance	47 %	15 %	20 %
Competence to take part in change management	0,900		
Competence to lead projects	0,888		
Understanding change management	0,886		
Competence to laed change management	0,877		
Understanding of project management	0,777	0,382	
Competence to take part in project management	0,774	0,419	
Skills in spreadsheet software		0,840	
Skills in software and text processing		0,832	
Basic informatics terminology	0,432	0,692	
Competence to take part in development of desicion support system methods and the use guidlines			0,874
Competence to work with software and desicion support system methods			0,814
Understanding desicion support methods and applications in patient management			0,548
Comptence to communicate electronically		0,459	0,494

Table 11. Descriptive Results for Design Thinking Competences (N=64).

Content (10)	Mean	Stadard Deviation	(N=64) Response rate Totally Disagree 1 (n) %	Disagree 2 (n)%	Partly agree 3 (n)%	Agree 4 (n)%	Totally agree 5 (n)%
Skills in service design process							
My way of working is customer oriented	4	0,9	(0) 0 %	(2)3 %	(20) 31 %	(19) 30 %	(23) 36 %
Skills for taking part in design process	3,1	1,0	(3)5 %	(14)22 %	(29) 45 %	(12) 19 %	(6) 9 %
Skills to cordinate resoursces and set goals							
Can identify needs and set goals to service design process	3,4	1,0	(2)3 %	(8)13 %	(27) 42 %	(17) 27 %	(10) 16 %
Can analyze and cordinate resources in service design process	3,2	0,9	(2)3 %	(8)13 %	(33) 52 %	(17) 27 %	(4) 6 %
Unerstand design thinking terms							
Understanding possible context for design process	3,0	1,0	(4)6 %	(16)25 %	(23) 36 %	(19) 30 %	(2) 3 %
Understanding design thinking and service design process terminology	3,0	1,0	(5)8 %	(15)23 %	(28) 44 %	(10) 16 %	(6) 9 %
Skills to iterate diagrams							
Can think and integrate diagrams in service design process	2,9	1,0	(4)6 %	(17)27 %	(30) 47 %	(8) 13%	(5) 8 %
Can create different models in service design process	2,8	1,0	(4)6 %	(24)38 %	(22) 34 %	(9) 14 %	(5) 8 %
Can test and re-evaluate models in service design process	3,0	1,0	(4)6 %	(15)23 %	(29) 45 %	(12) 19%	(4) 6 %
Can create arguments based on evidence in service design process	3,2	0,9	(3)5 %	(7)11 %	(30) 47 %	(20) 31 %	(4) 6 %

Design thinking competence

These results describe how students assessed their skills and competences in developing and designing digital services before the study unit (Table 11). Students had the highest competence in skills in service design in general (mean 3.5) and the lowest in iterate diagrams (mean 3.0).

Working customer oriented' had no totally disagree responses. Every other statement had responses ranging from totally disagree to totally agree. The best competences that students seemed to have were working customer oriented (mean 4.0), identifying needs and setting goals to service design process (mean 3.4), analysing and coordinating resources in service design process (mean 3.2) and creating arguments based on evidence in service design process (mean 3.2).

To reduce the variability observed in self-reports regarding design thinking competence, we conducted PCA (10 variables), which allowed us to identify two components explaining 83% of the analysis results. The following are the main components and explain the percentages of the results of the analysis: 1) Have skills to take part in service design process – 73%; and 2) Can identify needs and set goals to service design process in a customer oriented way - 10%. The saturated variables are explained components and presented in Table 12.

Discussion

Educating professionals to develop digital health and welfare services in multidisciplinary groups is crucial for developing competence in biomedical health informatics and design thinking. Our research provides an overview of these competences as assessed by students before taking part in the DeDiWe course.

The descriptive results show that there are variations in students' knowledge, understanding, skills and competences to work in a digital world. Students' skills in software for personal communication were high. In medicine, health and biosciences and health-systems organization, the theme 'basic IT competence' had a high mean, however, some students assessed their skills as low. In BMHI core knowledge, in the theme 'understanding and skills in literature retrieval and research methods', students mainly evaluated their skills as quite good. In the EU [6], nearly half of the population lacks skills to work in a digitalized manner. It is important to recognize students who need extra support in basic IT competences, digital communication skills, literature retrieval and research methods so that they can improve their skills in BMHI and DT.

Students assessed their understanding and competence in project and change management as low. In change management, there were higher values for taking part in change management than for understanding change management. These results are connected to the EQF [25] general professional competences, where level 6 includes 'take responsibility for managing professional development of individuals and groups', which is connected to project and change management. Furthermore, decision making is already one of the core areas in the EQF, and decision support systems are now a part of routine work. In level 6, there is currently not a demand for 'interface between different fields'. On the other hand, many authors are willing to apply multidisciplinary cooperation [1, 2, 3, 4, 5, 6, 8, 19, 20, 22, 23, 26], which is already on EQF level 6. These results are defining BMHI and DT competences in multidisciplinary perspectives and that´s why many of the subjects are described as understanding or having skills, which is lower than EQF 5 and 6 in general.

Table 12. Principal Components in Design Thinking Competences.

Variables (10)	1. Can actively take part to service design process	2. Can identify needs and set goals to service design process in a customer oriented way
Cummulative 83% of total variance	73 %	10 %
Can create different models in service design process	0,914	
Can test and re-evaluate models in service design process	0,914	
Uderstanding design thinking and service design process terminology	0,898	
Have skills to take part in design process	0,881	
Can think and itegrate diagrams in service design process	0,878	
Can analyse and cordinate resources in service design process	0,847	0,322
Understanding of possible context for design process	0,795	0,448
Can create arguments based on evidence in service design process	0,789	0,333
My way of working is customer oriented		0,934
Can identify needs and set goals to service design process	0,600	0,666

Students assessed their informatics or computer science, mathematics and biometry knowledge, skills and competence as good. Human functioning and health themes and competence to guide the client in social and health care were assessed as high. Again, almost all of the survey participants were studying health and social services; however, the results indicate that high school curricula might provide a great deal of knowledge with regard to human functioning and a general understanding about health care.

The quality and safety theme had the highest values in understanding patient safety initiatives. Evidence-based clinical decision making is the core of professional understanding in interdisciplinary health care [3, 4, 26], but it is not as common in social care. These contents are important to members of multidisciplinary groups that are developing eHealth and eWelfare services.

In DT competences, there were variations between totally disagree to totally agree. Almost all students felt that their work was customer oriented. This is important, because to achieve effective development and implementation, the customer-centric service culture in health care requires a human-centred design approach [9]. One-third of the students thought that they had at least some competences in the DT process. Students are in EQF level 5 and 6 5 [25], so all participants had general skills in development work. Students assessed skills for coordinating resources and setting goals as better to service design process. [27]. The scores for understanding terminology may have been low because such insight requires specific understanding of the service design process, integrating diagrams and the context of the design. Weneger [23] stated that there needs to be a common language to have fruitful cooperation in a development process. Educators need to take this into considerations and incorporate these subjects as part of their courses, so that students have opportunities for collaboration in service design. Students can acquire these competences based on general service knowledge in the health and social care sector; evidence-based argumentation is especially common in health care [3, 4, 26].

PCA was used to determine the principal components (PC) from measured responses to each instrument. The results and components were explored and compared to constructs used to design the original measurement tool. A twenty (12, 3, 3, 2) component structure showed the simplest solution and explained (80%, 68%, 73%) of variances in the BMHI and (83%) in the DT competence measurement tool. PCA was applied to every part of the measurement tool. A twelve-component structure explained 80% of the variance in the biomedical core knowledge and skills. A three-PC structure explained 68% of the variance in the biomedical and health informatics core knowledge and skills. A three-component structure explained 73% of the PC in informatics or computer science, mathematics and biometry. A two-component structure explained 83% of the DT competences. Cronbach's alpha values were satisfactory. Components were mapped to each theory base structure. There were variation between PA components contents and theory based themes.

The questionnaire used in this study was purposeful. It made use of categories in Mantas et al. [8, 9, 10], ECDL [7] and Design Thinking [28] theory, as well as EQF [25] levels. Social sector and non-health and social related questions were added. The IMIA sections have different numbers of variables because the BMHI core knowledge and skills comprise the largest content in the IMIA curriculum.

Quantitative data from the questionnaire were reported in this study. Findings from the qualitative data were previously reported [20]. Our results are not generalizable because of the small sample, which mainly reflects the opinions of the health care sector as represented by the student participants. However, these results imply that students have the knowledge, skills and competence to take part in multidisciplinary digital health and welfare service development. In this study, the competences were contextualized to bachelor studies. In the SFIA [22], all high level skills apply to the health informatics discipline; however, these results need to be contextualized and modified to suit the health industry.

The questionnaire was evaluated with Cronbach's alpha values and significant values, and the reliability of the questionnaire was found to be good. Alpha values that are too high indicate an insufficient number of responses (Table 1) [28]. In this study, there were only a few IT bachelor students and no IT engineer students. Aungst [19] found that there needs to be interprofessional teams of teachers to get interprofessional groups of students to participate in a study. Jones [21] found that there can be challenges to developing multidisciplinary teams. In the process of developing an SFIA in health informatics, large-scale cooperation and global understanding among the health industry needs to be part of the process [22]. Greater multidisciplinary co-operation among teachers and student groups is required in these DeDiWe courses, to get more multidisciplinary students.

Students were informed that completing the questionnaire was voluntary, but were encouraged to respond because of the importance of the project. This, as well as the need for English skills, might have affected the response rate and the results.

Conclusion

The descriptive results show that most students have good skills in e-communication, basic IT, literature retrieval and research methods. However, some students reported that they do not have these basic skills. It is important for teachers to take this variability into consideration so that they can support their students in the basics and help them to acquire more BMHI and DT knowledge, skills and competences in multidisciplinary environments. Multidisiplinary cooperation needs common terminologies. The PCA components can be the core areas of Universities of Applied Science Curricula in different professions taking part in developing eHealth and eWelfare services. The parts of measurement tools relied on item reliability and content validity testing. This study provided a base for further measurement tool revision and theoretical testing.

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Conflict of interest

The authors declare that there are no conflicts of interest.

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