International Journal of Science Education

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/tsed20

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To cite this article: Heleen van Ravenswaaij, Sanne ter Meulen-de Jong, Renske A. M. de Kleijn, Gonul Dilaver, Marieke F. van der Schaaf & Harold V. M. van Rijen (2024) Entry-level career paths in the life sciences: generic skills in Dutch job postings, International Journal of Science Education, 46:8, 795-814, DOI: 10.1080/09500693.2023.2259568

To link to this article: https://doi.org/10.1080/09500693.2023.2259568

INTERNATIONAL JOURNAL OF SCIENCE EDUCATION
2024, VOL. 46, NO. 8, 795–814
https://doi.org/10.1080/09500693.2023.2259568

Entry-level career paths in the life sciences: generic skills in Dutch job postings

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ABSTRACT

The importance of generic skills for life scientists is commonly recognised by employers, graduates, and higher education institutes. As it remains unclear which generic skills are relevant for different life sciences career paths, this study aims to give an overview to inform and inspire universities and students, by analysing 179 Dutch entry-level job postings. We deductively coded nine career paths, namely: life sciences industry, PhD-student, quality compliance, research-related, sales & business, communication/education, information technology, consultancy, and policy. We coded generic skills using an adapted categorisation consisting of 46 generic skills within four categories, which were: self, others, information, and tasks. The descriptive statistics and cluster analysis results showed that although language, communication, and collaboration were the most requested skills, differences in requested generic skills between career paths and cluster composition were observed as well. We concluded that although some generic skills are important in general, other generic skills are relevant for specific life sciences career paths. To educate skilled life scientists, universities should consider the flexible integration of these generic skills in their life sciences programmes.

ARTICLE HISTORY
Received 28 December 2022
Accepted 12 September 2023

KEYWORDS
Generic skills; life sciences graduates; career paths

Introduction

In recent years, universities have placed more emphasis on creating opportunities for students to develop their generic skills (Nabaho, 2017). Universities have traditionally focused mainly on the development of domain-specific knowledge and skills, often due to the limited room in existing curricula (Badcock et al., 2010). By focusing more on generic skills, universities respond to a call to action that took place in the last decades to educate students to be work-ready by developing accompanying skills (Cotronei-Baird, 2020). This call came partly from employers who placed increasing

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Supplemental data for this article can be accessed here https://doi.org/10.1080/09500693.2023.2259568.

importance upon generic skills compared to the domain-specific content (Badcock et al., 2010). A higher education qualification on its own could become insufficient for recently graduated students to distinguish themselves on the labour market (Kivunja, 2014; Succi & Canovi, 2020). For example, Raybould and Sheedy (2005) refer to the Higher Education Careers Services Unit in the U.K., which states that 'nearly two-thirds (64%) of postings on offer are open to graduates from any discipline (pp. 259). Unfortunately, a lack of generic skills in applicants have been noted by both employers of higher education graduates (Chamorro-Premuzic et al., 2010; Succi & Canovi, 2020; Thompson et al., 2018; Yap & Reston, 2014) and graduates themselves. A study, including 7062 young adults between 19 and 29 years old in the European Union, carried out by the Generation Europe Foundation (2010; in Cobo, 2013), reported that only one-third answered positively to the question whether they developed the right skills for entering the labour market. In addition, Pažur Aničić et al. (2023) found seven gaps in graduates' perceived skill level and perceived required skills for their profession, namely (1) critical thinking and reasoning, (2) general digital competences, (3) technical digital competences, (4) intercultural competences, (5) practical knowledge and its application, (6) adaptability, and (7) entrepreneurial spirit and leadership (pp. 11–14).

The main issue with generic skills in research and in practice is its conceptualisation (Badcock et al., 2010; Pažur Aničić et al., 2023). In literature, other terminology is used interchangeably, such as employability skills, graduate attributes, soft skills, transversal skills, key competencies, and twenty-first century skills (Cinque, 2016; Koyunlu Ünlü & Dökme, 2022; Murdoch-Eaton & Whittle, 2012; Nabaho, 2017; Raybould & Sheedy, 2005; Touloumakos, 2020). The boundaries and similarities of these different terms are not clearly defined. An example is competence, where some researchers view competences as a combination or application of knowledge and skills and others use it interchangeable with generic skills (Pažur Aničić et al., 2023). The consensus however is that these terms all refer to skills that are useful in a variety of domains, contexts, or situations, outside one's own domain (Gilbert et al., 2004). To illustrate, using a microscope to look at cells is highly related to specific life sciences domains, whereas the ability to plan can be used outside of the laboratory as well. Using a microscope is therefore considered a domain-specific skill and planning is, what we will call in the current paper, a generic skill. This distinction between domain-specific skills and generic skills is made to clarify the boundaries of generic skills, but it should be noted that generic skills are viewed as inseparable from knowledge domains. First, generic skills are best developed within a disciplinary domain, as opposed to developing them separately or without integrating them with domain-specific knowledge and skills (Jones, 2009). Second, it is debated whether generic skills and domain-specific skills can be separated in both teaching and assessment, as generic skills depend on the context in which they are required (Badcock et al., 2010). For instance, taking the planning example, differences in execution exist between planning a cell-based research project, a primary school outing, or a multiple course dinner. Billing (2003) describes this as variation in the skill's nature, which can also be related to differences in job demands. The automatic transferability of generic skills from one domain or context to another is therefore not evident (Bennett et al., 1999).

Commonly used examples of generic skills are collaboration, communication, prioritising, and reflecting (Bennett et al., 1999). Bennett et al. (1999) designed a categorisation of generic skills within four main categories, which are the management of self-,

management of others-, management of information-, and management of tasks-categories. Next to generic skills being beneficial for employability, these skills also appear to be necessary for lifelong learning (Murdoch-Eaton & Whittle, 2012) and to be successful in the job. White et al. (2013) for instance suggested that a successful biochemistry and molecular biology professional needs more than just technological abilities and understanding of fundamental concepts and theory. Many researchers have noted that different disciplines and jobs value different generic skills (Cotronei-Baird, 2020; Moore & Morton, 2017; Pažur Aničić et al., 2023). Moore and Morton (2017) state in their paper that universities would benefit from having knowledge about the context their graduates will participate in. The context of the current paper is the Graduate School of Life Sciences (GSLS) at Utrecht University in the Netherlands, and the aim of this paper is to provide insight into the generic skills that are relevant for university life sciences programmes and subsequent jobs.

There appears to be no consensus yet in the literature regarding which generic skills are most relevant for life scientists (Thompson et al., 2018; White et al., 2013). A higher education policy document from the U.K. listed that a biomedical science professional entering the labour market needs skills in 'communication, information technology, numeracy and data analysis, teamworking, critical thinking, setting tasks, problem solving and self-management' (Rees et al., 2006, pp. 46–47). The employability skills reported for starting biosciences professionals are slightly different, as data analysis and critical thinking are replaced by interpersonal skills, interdisciplinarity, and independent thinking, emphasising independent working skills over research-oriented skills. Thompson et al. (2018) studied which skills are important for applicants in the life sciences field identified by industry representatives. The top three skills were communication, integrity, and team skills. The Dutch Institute of Biology performed a national labour market research to gain insight in the relevant skills for life sciences graduates (van den Oever & Scheurwater, 2021). Their study combined data from 25 in-depth interviews and a survey completed by 97 employers leading in the life sciences & health domain participated. They found that in addition to graduates' disciplinary knowledge and competences, the employers valued the following skills as most important: language, reporting, collaborating, analytical thinking, communicating, and quick learning. In summary, although communication and collaboration are reported by all sources, there is still a large variety in the additional generic skills reported as relevant for life sciences professionals.

The large variety in the generic skills might relate to differences in the researched context, such as country and the life sciences careers paths under review. Cai (2013) noted that language and cultural skills might have different relevance in different labour markets. A job postings analysis for East Asian studies librarians in the U.S.A. and Canada showed for instance a high request for language proficiency (Li & Li, 2021). Regarding the career paths, life sciences graduates are employable in many areas in private and public sectors such as universities, laboratories, pharmaceutical industry, medical devices industry, sales and marketing, and teaching (Rees et al., 2006). Not all these areas are focused on research. Fuhrmann et al. (2011) found that university life sciences graduates consider career paths outside academia. Of their 469 participating graduates, 92% strongly considered a research career path and 71% strongly considered a non-research career path, with 63% strongly considering both. More than 80% of life sciences PhDs in that study did not remain in an academic position

5–6 years after graduating, indicating the high occurrence of professionals switching between careers paths. In the study of Mcgee and Keller (2007), a similar division between career paths was found. Of the 26 undergraduate medical students, 15 continued in research or maintained interest in research, nine were M.D., and two continued in either business or teaching. Fuhrmann et al. (2011) emphasise the necessity of generic skills in all career paths, but they do not elaborate on possible differences in the relevant skills for various career paths. Van den Oever and Scheurwater (2021) did make a distinction within life sciences and health domains career paths. They found that for communication and education careers, verbal presentation skills were additionally relevant. For policy and processes careers, inter- and multidisciplinary thinking was important.

Current study

Due to the differences in reported relevant generic skills for life sciences careers, educators and students might lack a clear overview and understanding of which generic skills are relevant for their interests and careers. This knowledge can help students in choosing and working towards a specific career path (Thompson et al., 2018), and it can help educators to make decisions about which generic skills should explicitly be integrated in disciplinary university settings (Chamorro-Premuzic et al., 2010). The current study therefore aims to inform and inspire universities regarding the generic skills that could aid the development of skilled life scientists. We analysed Dutch job postings to provide an answer to the following research question: Which entry-level career paths can be distinguished in Dutch life sciences job postings and which generic skills are requested from applicants in the different career paths?

Materials and methods

Job postings selection

A descriptive research design with a document desk search of job postings was held using the search term 'life sciences' in two search engines (i.e. LinkedIn and Indeed). The job postings were collected in 2019 at two moments during two consecutive weeks: (1) the last week of May and first week of June, and (2) the last two weeks of September. We used three inclusion criteria: (1) the job posting explicitly requested a higher education degree within life sciences as previous education or, when previous education was not explicitly mentioned, the job posting indicated the life sciences domain (e.g. sales and recruitment jobs in life sciences domain), (2) a maximum of 2 years' work experience, and (3) the job is located in the Netherlands.

Sample

The search and selection procedure resulted in a total of 251 job postings, of which 72 job postings were identical and therefore removed from the final dataset. The final dataset consisted of 179 unique job postings. All the job postings that mentioned work hours ($n = 121$, 67.6%) requested 32 or more hours. The type of contract was either not mentioned ($n = 98$, 54.7%), temporary ($n = 59$, 33.0%), or temporary with the possibility to

Table 1. Overview of requested previous education: domain and degree.

Variable	Options from job postings	#	%
Education domain	Scientific	15	8.4
	Life Sciences or … (other field(s))	54	30.2
	Life Sciences	24	13.4
	Specific Life Sciences discipline or … (other discipline(s))	48	26.8
	Specific Life Sciences discipline	7	3.9
	No data/ no requirements	31	17.3
Education degree	University Master	60	33.5
	University Bachelor or Master	40	22.3
	Higher education (University of Applied Sciences/ University Master)	32	17.9
	University Bachelor	21	11.7
	University of Applied Sciences	9	5.1
	Degree	5	2.8
	College advance	1	0.6
	No data	11	6.1

change to permanent in the future ($n = 22$, 12.3%). Salary was not mentioned in 118 (65.9%) of the job postings. In the job postings where salary was mentioned, most ($n = 48$, 26.8%) described a range in monthly salary, with a mean of €2948 (*Standard Deviation* = €440.90). Table 1 provides an overview of the domain and degree of education requested in the 179 job postings.

Coding procedure

The 179 job postings' texts were placed in a text editor and Microsoft Excel. Each row represented a job posting and the columns represented the following variables which were directly copied from the job postings texts: title of job posting, company name, company location, number of hours, contract type, salary, education, the text including the generic skills, and separate generic skills. The first and second author used content analysis to code the generic skills and career paths a priori from the job postings' texts (Stemler, 2000).

Generic skills coding

The literal generic skills from the texts were taken as segments and were coded using an existing categorisation by Dunne (in Bennett et al., 1999) with 36 generic skills as basis. Ten codes emerged during the coding procedure and were added as extension of the categorisation (see skills with an asterisk in Table 2), resulting in 46 generic skills (see Table 2). A new skill was added if the skill occurred more than four times in the total dataset, if not, they were coded as *else*. When a skill could be interpreted as multiple different generic skills, it was coded as *else* as well. In 22 job postings (12.3%), at least one generic skill was coded as *else*.

Before coding all job postings, we went through three distinct phases: (1) data familiarisation, (2) practice, and (3) inter-coder reliability. During data familiarisation, both researchers coded two job postings before a meeting and four during a meeting. In the meeting, differences and difficulties were discussed and resolved immediately. During practice, ten job postings were coded by both researchers separately and afterwards qualitatively compared and discussed to find consensus. This was repeated twice with different job postings. During the last phase, the inter-coder reliability percentage agreement was calculated based on 44 separately coded job postings by both researchers. These 44 job postings resulted in a total of 185 coded generic skills, of which initially 79%

Table 2. Codebook based on the categorisation of Dunne (in Bennett et al., 1999) with the generic skill name and the illustration in terms of 'student is skilled in'. An asterisk (*) denoted an additional generic skill to the categorisation, a circumflex accent (^) indicated that a generic skill was placed in a different management of-category.

Management of self-category	
Time-management	Estimate the time necessary to perform a task.
Goal-setting	Set a personal goal to work on.
Responsibility	Take responsibility over own work / learning, self-motivate.
Listening	Understand others by listening to others.
Learning	Develop / carry out strategies to learn new things.
Flexibility	Deal with new situations / ambiguity, think outside the box.
Transferability	Transfer knowledge / skills, etc. to new situations.
Planning	Plan actions to reach a (long-term) goal.
Reflecting	Critically think about own actions / consequences / intentions.
Handling feedback	Use received feedback in an effective manner.
Coping with stress	Handle and cope with stress.
Initiative*	Take initiative, work independently, be proactive.
Accuracy*	Work accurately, make few to none mistakes.
Organising*	Organise / structure work effectively, do administration work.
Research*	Perform research cycle activities, experiment, use methods.
Management of others-category	
Agreeing	Meet deadlines, work reliable, do what was promised.
Respecting	Accept others, be open to other perspectives / opinions.
Adapting	Adjust to others' / teams' / clients' needs, desires, or decisions.
Justifying	Justify and /or show determination of views or actions.
Leadership	Take the lead, assign tasks, make decisions, manage others.
Negotiating	Reach the middle ground, create a win-win situation.
Giving feedback	Offer useful feedback to others.
Collaborating	Working / learning with others (e.g. different backgrounds).
Supporting	Creating learning opportunities for others, helping others to learn.
Interpersonal*	Develop / maintain relationships, social skills, use empathy.
Management of information-category	
Selecting	Select / gather information.
Technology	Use technology (e.g. software, programming skills).
Media	Use media, data visualisation.
Data handling	Represent / document data, use statistics / modelling techniques.
Language	Master a language.
Interpreting	Understand information and /or data, draw conclusions.
Communicating	Present, write, discuss information.
Critical	Critically review information.
Creativity	Use information creatively.
Analysing^	Think analytically, analyse (e.g. data), examine, identify problems.
Management of tasks-category	
Key features	Identify important aspects of a task.
Conceptualising	Understand the requirements and content of a task.
Prioritising	Define / sequence the important aspects for task completion.
Options	Formulate different options to successfully complete a task.
Executing	Execute procedures, actions, organisation, implementation.
Assessing	Assess the progress / result of a task.
Problem solving*	Solve a problem, solution driven.
Result driven*	Focus on the result, goal oriented.
Details*	Pay attention to details in a task / work.
Efficient*	Complete a task efficiently / effectively.
Project-management*	Manage or organise a project.

was coded as the same generic skill. Differences were discussed with the intention to come to an agreement between 85% and 90%, which is considered sufficient (Miles et al., 2018). With discussion, an agreement of 88% was reached. After these three phases, the first author coded all 179 job postings individually.

Table 3. Nine career paths including their abbreviations, illustrations, and prevalence.

Career path	Abbreviation	Illustration	Number of job postings (% of total)
1. Life sciences industry	LSI	Non-academic research institutes, for example biopharma and biotech companies.	38 (20.7%)
2. PhD-student	PhD	A paid position between 3–5 years resulting in a doctoral degree.	33 (17.9%)
3. Quality compliance	QC	Includes quality assurance, quality control, quality compliance and regulatory affairs functions.	27 (14.7%)
4. Research-related	RR	No research execution, but related to research, for example clinical research organisations and project-manager functions.	22 (12.0%)
5. Sales & business	SB	Sales jobs, account managers, and business development jobs in life sciences contexts.	21 (11.4%)
6. Communication/ education	CE	Jobs in communication or education, such as teaching roles in university.	13 (7.1%)
7. Information technology	IT	Software development and coding (e.g. statistical analyses).	11 (6.0%)
8. Consultancy	Con	Consultancy and advisor roles in life sciences contexts.	6 (3.3%)
9. Policy	Pol	Working on policy processes, such as policy documents and educational processes.	2 (1.1%)

Career paths coding

The first and second author coded in collaboration the job postings' career paths. We deducted nine career paths, which can be found in Table 3, including the abbreviations used in this study, examples to illustrate the career paths, and their prevalence in the dataset. Eleven job postings (6.0%) could not be sorted in one of the nine career paths and were coded as other. The prevalence in this table adds up to 184, not to 179 as before, as five of the job postings were sorted in two different career paths.

Data analyses and visualisation

Using IBM SPSS Statistics version 24, we generated variables for the total number of generic skills per posting, the number of unique generic skills per posting, and the number of generic skills in each generic skills category (i.e. self, others, information, and tasks). We focused on the unique generic skills, as in some job postings the same generic skill was mentioned multiple times. Proficiency in the English and Dutch languages is one such example, where two separate requirements both fall in the same generic skill language. In the analysis, language was in this case added one time for this posting, instead of twice.

Results include descriptive statistics, absolute numbers, frequencies, and rankings of the unique generic skills' categories, generic skills within these categories, and the career paths. To link the four generic skills' categories (i.e. self, others, information, and tasks) to the nine career paths, a two-step cluster analysis was performed. The cluster analysis included four dichotomous variables, indicating whether (i.e. yes or no) the job posting requested at least one skill from the management of self-, others-, information-, and tasks-categories. Schwarz's Bayesian Criterion (BIC) and the Akaike Information Criterion (AIC) were used to determine the number of clusters, which are both based on the log-likelihood distance measure. The statistical software provides an estimation of the cluster quality, where a score between .5 and 1.0 is labelled as a good cluster solution. We reported on the composition of the clusters (i.e. the combination of generic skills categories that are present in

the cluster) and the prevalence for these clusters for the five most common career paths. Next, the occurrence of the ten most requested generic skills for these five career paths are given. Lastly, skill profiles based on a comparison of the highest and lowest percentages of the top ten requested skills for the five most common career paths are described.

Results

Generic skills categories

Table 4 provides the prevalence of job postings requesting at least one generic skill in the self-, others-, information-, and tasks-categories. The highest prevalence was the information-category, where in 90.5% of the job postings ($n = 162$) at least one skill from this category was requested. Generic skills from the others- and self-categories were at least once requested in 53.6% and 52.5%, respectively of the job postings. In 29.1% of the job postings, at least one skill of the tasks-category was requested.

Generic skills

We found that on average four generic skills were requested in a job posting (*Mean* = 4.1, *Standard Deviation* = 3.0, Min = 0, Max = 14). Figure 1 shows the distribution in more detail, indicating that, for instance, eight job postings requested no generic skills and one job posting 14.

The prevalence of all 46 generic skills can be found in Figure A in the supplemental online materials. The three generic skills with the highest prevalence in each generic skills category are shown in Table 4. For the information-category, the highest five are shown to include the overall ten most requested generic skills (see last column in Table 4 for overall ranking). The generic skills requested the most were language and communicating, which are both part of the information-category. Collaborating, part of the others-category, was the third-most requested skill. The fourth and fifth most requested skills were initiative and organising, both part of the self-category. Result driven was the highest generic skill in the tasks-category, ranked at eight. Of the 46 generic skills in total, 24 generic skills were requested in less than 5% of the job postings.

Table 4. Prevalence of the four generic skills categories requested at least once in the total number of job postings ($N = 179$) with the highest occurring generic skills for each category.

Generic skills category	In # of job postings and prevalence (%)	Highest occurring generic skill	In # of job postings and prevalence (%)	Ranking of total
Information	162 (90.5%)	Language	124 (69.3%)	1
		Communicating	105 (58.7%)	2
		Analysing	24 (13.4%)	7
		Technology	21 (11.7%)	9
		Creativity	19 (10.6%)	10
Others	96 (53.6%)	Collaborating	74 (41.3%)	3
		Interpersonal	30 (16.8%)	6
		Adapting	12 (6.7%)	15
Self	94 (52.5%)	Initiative	58 (32.4%)	4
		Organising	38 (21.2%)	5
		Flexibility	17 (9.5%)	11
Tasks	52 (29.1%)	Result driven	21 (11.7%)	8
		Details	13 (7.3%)	13
		Problem solving	9 (5.0%)	18

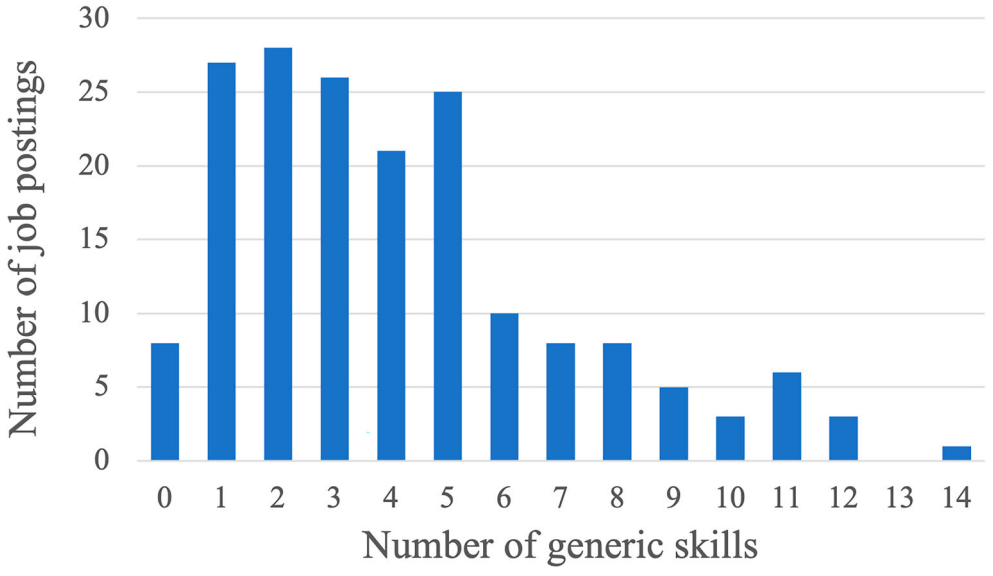

Figure 1. Number of generic skills (between 0 and 14) found in all job postings ($N = 179$).

Generic skills categories cluster composition

The exploratory two-step cluster analysis resulted in a good cluster solution (i.e. cluster quality of .9), separating seven different clusters. These seven clusters, their compositions, and prevalences are presented in Table 5 and visually represented in Figure 2 (a–h). In four of the seven clusters, one specific generic skill category could, based on the data, not exclusively be included, or excluded from the cluster. To indicate these 'indifferent' categories, brackets were used in Table 5 and striped blocks in Figure 2. To illustrate, the *self (and others)* cluster contains job postings with at least one self-category skill, no information-category and tasks-category skills, but can include job postings both with and without at least one skill from the others-category.

The *information only* cluster showed the highest prevalence of 23.5%, indicating that many job postings requested only skills from the information-category. The clusters with the second (i.e. *no tasks*; 20.1%) and third (i.e. *all (except information)*; 17.9%) highest prevalence however showed a different composition. They represented job postings

Table 5. Cluster prevalence and composition interpretation, where X represents the generic skills category being part of the cluster. X between brackets indicates an 'indifferent' category, where both job postings including and excluding this category are part of the cluster.

Clusters	Prevalence		Management of			
Job posting requesting skills:	#	%	Self	Others	Information	Tasks
All (except information) (Figure 2(a))	32	17.9	X	X	(X)	X
No tasks (Figure 2(b))	36	20.1	X	X	X	
No others (and tasks) (Figure 2(c))	20	11.2	X		X	(X)
No self (and others) (Figure 2(d))	11	6.1		(X)	X	X
Others & information (Figure 2(e))	22	12.3		X	X	
Self (and others) only (Figure 2(f))	16	8.9	X	(X)		
Information only (Figure 2(g))	42	23.5			X	

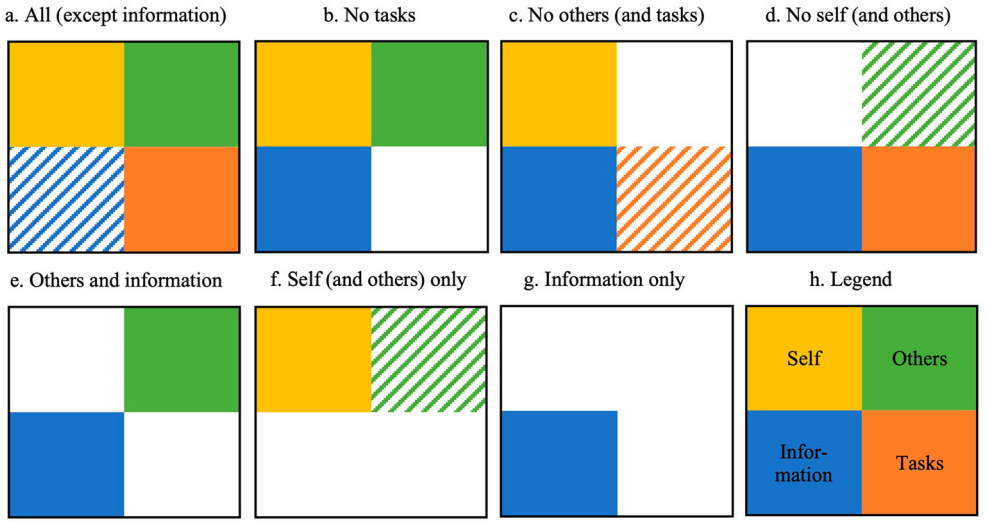

Figure 2. (a–h). Seven cluster compositions of the management of self (top left), management of others (top right), management of information (bottom left), and management of tasks (bottom right) categories. Striped blocks indicate an 'indifferent' category, where both job postings including and excluding this category are part of the cluster.

requesting a combination of generic skills from multiple categories. The *all (except information)* cluster represented job postings in which generic skills from either all generic skills categories were requested or from three categories excluding the information-category (i.e. the self-, other-, and task-categories). Those representing the *no tasks* cluster requested at least one skill of the self-, others-, and information-category, but none from the tasks-category. This combination of three categories was present in two other clusters as well, namely the *no others (and tasks)*, and *no self (and others)* clusters, with a combined prevalence of 17.3%. A combination of skills from the others- and information-categories was requested in 12.3% of the job postings and therefore named the *others & information* cluster. In 8.9% of the job postings, mainly skills from the self-category were requested, sometimes in combination with skills from the others-category. This cluster was called *self (and others) only*.

Generic skills clusters in career paths

Nine life sciences career paths were found (see Table 3), namely (1) life sciences industry, (2) PhD-student, (3) quality compliance, (4) research-related, (5) sales & business, (6) communication/education, (7) information technology, (8) consultancy, and (9) policy. For the five most often found career paths, the prevalence of the seven clusters is provided in Table 6. A complete overview of the cluster prevalence in all career paths can be found in Table A in the supplemental online materials. For the life sciences industry career path, all clusters were somewhat equally represented, indicating that there was not a clear skill request for this career path in our data. For the quality compliance career path, we observed that a relatively large proportion of the job postings requested only skills from the information-category (*information only*; 44.4%). This

emphasis on *information only* was also found for the PhD-student career path, albeit it with a lower percentage of the PhD-student job postings (27.3%) compared to quality compliance jobs. The requested skills for the research-related career path had a different emphasis compared to the other career paths, as it appeared to place less emphasis on *information only*. The two highest clusters in this career path were *others & information* (31.8%) and *all (or no information)* (27.3%), indicating a request for a combination of skills instead of focusing on one category. The sales & business career path appeared more diffuse, as four clusters occurred between four and six times and three clusters not at all or once.

Generic skills in career paths

The percentages and rankings of the ten most frequent requested generic skills in relation to the five most found career paths are presented in Table 7. The numbers for the other career paths can be found in Table B in the supplemental online materials. The ranking position of the skill was based on the skills' prevalence compared to the other skills. The generic skills are listed from highest to lowest, according to their prevalence across all job postings. Visual representations are provided in Figure 3 from the generic skills' perspective and in Figure 4 from the career paths' perspective.

In all career paths, language and communication were requested most often compared to the other generic skills. Collaborating, initiative, and organising were often found in the top five of each career path (see Table 7). Moreover, differences between the career paths were observed as well. The skill accuracy was not part of the overall top ten, but was considered relevant in the life sciences industry career path (ranked fifth, eight postings, 21.1%), substituting the skill organising. For the research-related career path, interpersonal skills were ranked fourth (nine postings, 40.9%), whereas initiative is ranked in sixth place. Job postings in the sales & business career path more often requested interpersonal skills (third rank, seven postings, 33.3%) and being result driven (fifth rank, five postings, 23.8%), instead of collaborating and organising skills (shared sixth rank, four postings, 19%).

The visual representations (see Figures 3 and 4) of the generic skills and career paths show the different emphases of generic skills in each career path. Although language was requested in all career paths, it had the highest occurrence in quality compliance and sales & business career paths. Communicating and collaborating had the highest occurrence in the career paths for PhD-student and research-related, and lowest in sales &

Table 6. Prevalence of the seven generic skills clusters in the five most often found career paths: life sciences industry (LSI), PhD-student (PhD), quality compliance (QC), research-related (RR), sales & business (SB).

	LSI		PhD		QC		RR		SB	
Job posting requesting:	#	%	#	%	#	%	#	%	#	%
Information only	7	18.4	9	27.3	12	44.4	1	4.5	6	28.6
No tasks	7	18.4	6	18.2	4	14.8	3	13.6	5	23.8
All (or no information)	5	13.2	6	18.2	3	11.1	6	27.3	4	19.0
Others & information	4	10.5	5	15.2	3	11.1	7	31.8	1	4.8
No others (and tasks)	6	15.8	3	9.1	2	7.4	1	4.5	4	19.0
Self (and others) only	4	10.5	4	12.1	2	7.4	2	9.1	1	4.8
No self (and others)	5	13.2	0	0	1	3.7	2	9.1	0	0
Total	38	100	33	100	27	100	22	100	21	100

Table 7. Percentages and ranking of job postings requesting the overall top ten generic skills for the five most often found career paths.

	LSI ($n = 38$)		PhD ($n = 33$)		QC ($n = 27$)		RR ($n = 22$)		SB ($n = 21$)	
Generic skill	%	Rank	%	Rank	%	Rank	%	Rank	%	Rank
Language	57.9	1	66.7	2	85.2	1	68.2	2	95.2	1
Communicating	47.4	2	69.7	1	63.0	2	72.7	1	42.9	2
Collaborating	44.7	3	51.5	3	37.0	3	54.5	3	19.0	6
Initiative	34.2	4	36.4	4	22.2	4	27.3	6	33.3	3
Organising	15.8	6	27.3	5	18.5	5	36.4	5	19.0	6
Interpersonal	2.6	>10	15.2	8	11.1	8	40.9	4	33.3	3
Analysing	7.9	>10	6.1	>10	14.8	6	13.6	9	4.8	>10
Result driven	13.2	8	3.0	>10	7.4	>10	4.5	>10	23.8	5
Technology	2.6	>10	24.2	6	14.8	6	13.6	9	0	n.a.
Creativity	5.3	>10	18.2	7	3.7	>10	18.2	7	9.5	>10

business. Initiative was least requested in quality compliance job postings, even though the difference for this skill is rather small between the career paths. Organising skills appeared most relevant for research-related and PhD-student careers and interpersonal skills for research-related and sales & business careers.

Career paths' generic skills profiles

The highest and lowest percentages of the top ten overall requested skills in the career paths (see Figure 4) indicated that for life sciences industry careers, taking initiative and being result driven was requested relatively often compared to other careers, whereas language, communicating, organising, interpersonal, technology, and creativity was requested relatively less often compared to other careers. The PhD-student positions requested relatively more often communicating, collaborating, initiative, technology, and creativity skills, and requested less often to be result driven, compared to the other career paths. The quality compliance career path had a relatively high request for language and analysing skills, and a lower request for taking initiative and creativity. Skills that were requested more often in the research-related career path were

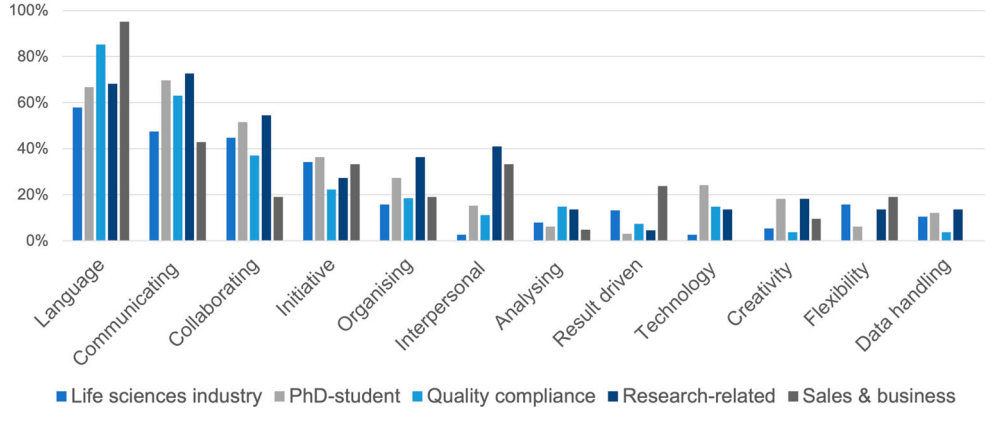

Figure 3. Percentages of the five most often found career paths and the top ten requested generic skills.

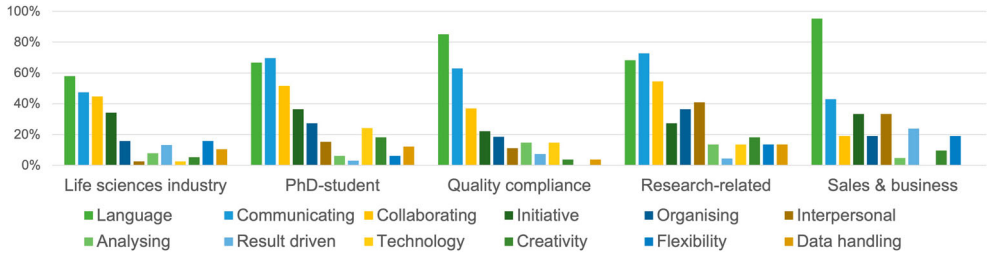

Figure 4. Percentages of the top ten requested generic skills in the five most often found career paths.

communicating, collaborating, organising, interpersonal, analysing, and creativity. In this career path, no skills have been identified that were less frequently requested compared to the skills in the other career paths. For sales & business jobs, language, interpersonal, and being result driven was requested more often, whereas communicating, collaborating, analysing, and technology skills were requested less compared to the other career paths.

Discussion

Overall, researchers agree upon the importance of generic skills for life sciences graduates next to their disciplinary knowledge and competences. However, there is no consensus regarding which skills belong to this broader generic skill set (Thompson et al., 2018; White et al., 2013). The purpose of this study was therefore to provide insight in the generic skills relevant for Dutch entry-level life sciences careers.

We found that although the generic skills which were requested most were language, communication, and collaboration, other generic skills were requested in different careers as well. The finding that communication and collaboration are important (life sciences) generic skills, is in accordance with previous studies (Rees et al., 2006; Succi & Canovi, 2020; Thompson et al., 2018; van den Oever & Scheurwater, 2021). Language, which was requested often in our job postings, is however not often reported in international literature as an important generic skill. The Dutch Institute of Biology on the other hand did report language as an important skill (van den Oever & Scheurwater, 2021), which might indicate that more explicit emphasis is placed on language in the Netherlands compared to particularly English-speaking countries (Cai, 2013). An Australian job postings analysis for environmental science jobs did not include language in their skills framework (Stewart, 2021), whereas many job postings in our dataset requested both Dutch and English language skills. Additional country-related nuances have been observed by Billing (2003), who analysed employer surveys. This study reported that problem-solving ranked much higher in the United Kingdom (i.e. third) compared to the United States and Europe (i.e. eighth and ninth). Another possible explanation is the influence of the domain under review. Li and Li (2021) for instance found language being requested in East Asian studies librarians in U.S.A. and Canadian job postings and explain this finding by a decline in requested knowledge and experience in the job. The domain of life sciences, and in our study specifically quality compliance and sales and business jobs, could be internationally oriented and therefore explicitly request (English) language skills.

Relevance of the generic skills within the information-category was reflected in the seven clusters found, as almost all clusters included skills from this category. Skills such as taking initiative and creativity were in the top ten of skills requested by our job postings, but not often mentioned in other labour market research. Remarkably, graduates in biomedicine and health sciences in the study of Pažur Aničić et al. (2023) mentioned adapting and acting in new situations and working autonomously, among others, as required competences. The researchers suggest that this might relate to the stressful situations that these graduates face in their work. Whether these generic skills can be interpretated as the same skills remain however difficult to determine. As many different terms are used interchangeably for generic skills (Cinque, 2016; Murdoch-Eaton & Whittle, 2012; Nabaho, 2017), differences in what is considered a generic skill might arise. An example is integrity, which was in the study of Thompson et al. (2018) part of the top three, but in our study not part of the generic skill categorisation used and therefore not considered a generic skill.

Thompson et al. (2018) concluded that life sciences students are underinformed about career paths other than the academic research path. The career paths we found were, in order of most common to least: life sciences industry, PhD-student, quality compliance, research-related, sales & business, communication/education, information technology, consultancy, and policy. Although PhD-student positions were common, these results showed that life sciences graduates have many career options outside academia as well. When linking these career paths to the seven clusters, we found that for quality compliance and research-related careers, having only information-skills was relatively more important compared to other clusters and other career paths. The job postings in the research-related career path requested more often clusters including skills from the others-category. The life sciences industry career path appeared to value the *no self* cluster relatively often compared to the other careers. Not much is reported in literature about the relevant generic skills for career paths within a specific domain. Rios et al. (2020) for instance only made a distinction between degree fields of arts and humanities, business, education, social sciences, S.T.E.M., and other. They reported, in alignment with our results, that collaboration was less required in business compared to the S.T.E.M. field. Interestingly, van den Oever and Scheurwater (2021) made a distinction within life sciences, but only included communication and education- and policy and processes careers. We found however a relatively low number of job postings for both career paths (respectively 7% and 1% of all postings). Regarding the specific generic skills, nuances between the career paths showed that accuracy was requested often in the life sciences industry career paths, but not in the other careers. Taking initiative and interpersonal skills were requested most in sales & business careers. Interpersonal skills were also relatively more important in the research-related career path. These results indicate that different career paths vary in the generic skills they emphasise.

Study limitations and future directions

The use of job postings in the current study is advantageous since they are widely accessible and directly linked to the hiring context and could provide a more accurate insight on the generic skills searched for by employers compared to interviews or surveys (Rios

et al., 2020). However, job postings for research purposes have methodological issues as well. First, the generic skills requested might not be a true reflection of what is required in the job. One example is that word count limitations in job postings could prevent employers from requesting all generic skills they would like to see in future employees (Rios et al., 2020). This could indicate that job postings include mainly skills which are not evident or not often present in applicants (Billing, 2003), or exclude generic skills which are deemed evident in the life sciences domain. To illustrate, in our study many job postings requested a low number of generic skills or all within one skill-category. In addition, those who write job postings consciously choose the words and information they relay in job postings to attract future employees' attention and encourage them to apply (Backhaus, 2004). Job postings could consequently include skills which are not necessary to perform the job or include a more extensive list of skills and abilities to compensate for a lack of required educational degree or experience (Li & Li, 2021). This implies that we cannot interpret our results as a true reflection of the generic skills required in different career paths, but only as an indication of what employers find relevant to relay to applicants. Although this indication is still useful for guiding curriculum design and for graduates applying for jobs, Rios et al. (2020) justifiably mentioned that further research is useful to understand the formulation of job postings. A suggestion is to compare the generic skills requested in job postings with the generic skills required in the job execution, for instance by interviewing employers.

Second, in the current study, each generic skill described in the job postings has been valued equally important. The job postings did not provide sufficient information about which generic skills would be viewed as more important for the specific job. Expert ranking could be performed to provide insight in the importance of the generic skills. Another indication for importance could be the number of times a generic skill is described in one job posting. However, hardly any job posting described a generic skill more than once in an individual job posting. One exception was communication, which was also one of the generic skills with the highest prevalence in general. Communication might be a more complex skill, consisting of several subskills, which are all important in the light of graduates' careers. In the job postings analysed in the current study, presenting, writing, and discussing were for instance requested and all coded as communication. Other researchers reported multiple subskills as well. For biomedical research careers, a distinction is made between spontaneous oral conversation skills (e.g. with colleagues), planned speech (e.g. presentations), and written conversation skills (e.g. research papers) (Cameron et al., 2015). Even within the subskill written communication, a distinction can be made between writing for different audiences and different purposes (Moore & Morton, 2017). In two studies with a similar research methodology but within different fields, a difference in emphasis within communication was found. In social media jobs written communication was requested the most (Verma et al., 2021), whereas in artificial intelligence and machine learning jobs, general and verbal communication was requested more often (Verma et al., 2022). Future research and discussions would therefore benefit from a more in-depth conceptualisation of communication for life sciences careers, as this might inform universities on how to design their communication education.

Theoretically, due to the nature of generic skills as being useful in multiple contexts, comparisons between different contexts in the literature should be feasible. In practice

however, as shown in this paper, this might only be true for the topmost requested generic skills, but not for remaining relevant skills. This relates to the difficult conceptualisation of generic skills (Badcock et al., 2010; Cinque, 2016; Murdoch-Eaton & Whittle, 2012; Nabaho, 2017; Pažur Aničić et al., 2023). Although an existing categorisation for generic skills was used in our study to mitigate this issue, the exact wording still needs to be interpreted to code the generic skills in the job postings. Different perspectives on generic skills in life sciences career paths could be researched further, as a disconnect between different stakeholders may exist (Thompson et al., 2018). A suggestion is to combine interviews with employers who published the job postings, graduates who interpret the job postings, and employees who recently started the job. Interviews with educators and university leaders can provide more understanding regarding the integration of generic skills in university curricula.

Implications

As a university, we need to be aware of what we train students for after graduation, as we have the task to educate our students for society (Ramaley, 2014). Educators and students therefore need to know the importance of generic skills development and the relevance for different life sciences career paths, for which they can use our results. Next to knowing the importance of generic skills, Holmegaard et al. (2014) suggest that younger students need more accurate information about careers after a science-related study and what is requested in these careers. Communicating different careers and generic skill development opportunities with prospective students could therefore be beneficial.

Optimising curricula for generic skills development implies creating educational opportunities for students to develop their generic skills. Students already practice and apply generic skills in many domain-specific programme elements, such as internships and assignments. However, these skills are often not explicitly instructed, practiced, and (formatively) assessed. A way to make skill education more explicit for students and to foster integration is to create generic skills curricula in existing disciplinary settings (Jones, 2009). This is mainly feasible for generic skills which are relevant for all students, such as collaboration and communication. Incorporating all generic skills in existing programmes is however impossible due to the large number of potentially relevant skills (Rios et al., 2020). Programmes should therefore at least offer opportunities to develop these skills by providing educational activities which require students to apply skills (Crebert et al., 2004), for example in complex problem-solving activities (Ramaley, 2014).

Next to opportunities, students need self-regulation abilities and guidance to know which opportunities to seize, to decide which generic skills to develop, and to continue developing their skills. Self-regulation abilities include setting goals, selecting strategies and practice opportunities, and assessing progress for instance by reflecting (Zimmerman, 2008). This cycle increases students' agency and preparedness for lifelong learning (Sandars, 2009). Setting generic skills goals can for instance be linked to domain-specific elements such as internships, where students set their own goals and are explicitly guided in this process by a university teacher or internship supervisor. As transfer of generic skills is not evident (Bennett et al., 1999), reflection practices can support transferability

by analysing skills within one context and applying them in new contexts. Reflection can furthermore help students with articulating one's own skill set, which is especially useful in relation to job applications and interviews.

Conclusion

To conclude, the present study provided an identification of nine life sciences entry-level career paths (i.e. life sciences industry, PhD-student, quality compliance, research-related, sales & business, communication/education, information technology, consultancy, and policy) and an overview of requested generic skills. Like other disciplines, the current study found that this means integrating language, communication, and collaboration skills in the disciplinary curriculum. However, creating opportunities for life sciences students to develop skills such as taking initiative, organising, creativity, and analysing is necessary as well. We emphasise the variety of careers life sciences graduates can pursue, and the importance of generic skills in students' preparation for becoming a successful life science professional.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Authors contribution

HR and SM collected the data, coded the data, and discussed the results. All authors designed the research project, interpreted the results, contributed to the practical implications, and commented on the manuscript.

Data availability

Data is available in the repository via https://figshare.com/projects/Generic_skills_in_Life_Sciences_careers/155255

Ethics statement

This manuscript used publicly available data and does not include any data collected from humans (i.e. no human subjects research) and therefore no ethics approval was needed.

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