

Finding Appropriate Serious Games in Vocational Education and Training: A Conceptual Approach

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Abstract: Stakeholders in vocational training are required to provide appropriate learning opportunities that can be used to develop the needed skills induced by technological change and thereto affected changes in the type of jobs, skill needs, activities, and other economic effects. In light of this, serious games have enormous potential, as they can simulate complex real-life situations without disrupting operations, but in a playful and motivating way, and with adaption to the individual needs of the users. This paper explores the question, how to find appropriate serious games matching the needs for a specific job and skill level. Within the research project “Serious Games for Vocational Education and Training” funded by the German Ministry for Science and Education, the Serious Games-Information Center (SG-IC, a classical web-based information system in form of a portal) and its underlying Serious Games Metadata Format (SG-MDF), as semantic basis for the description and retrieval of serious games, is enhanced according to the characteristics and needs in the field of vocational education and training (VET). Educational stakeholders can use the search engine to identify personalized game-based learning opportunities for their individual target groups. The identification of appropriate educational games is based on classifications of occupations, and skill levels on the learning side, and metadata information for the games on the gaming side (i.e. target user group, game genre, learning topics and additional keywords). The paper motivates the use of metadata and classification systems and presents the results of a literature search and overview of established classification systems of occupations, with a focus on Germany, but with correspondence to international systems. Based on that analytic work, an application profile ‘vocational education and training’ as an added ‘variant’ of the SG-MDF has been elaborated and integrated within the SG-IC as search engine for educational games for vocational training. Hereto serious games are matched with a database of occupational fields as defined by the Federal Institute for Vocational Education and Training, and main activity as defined by the microcensus, the largest annual household survey of official statistics in Germany.

Keywords: Vocational education and training, serious games, educational games, Serious Games Information Center, Serious Games Metadata Format, classification of occupations.

1. Motivation – Pedagogical discourse

Induced by the increased use of digital technologies and adapted value chains, the working world and employment is rapidly changing. It is assumed that jobs, as well as activities in almost all industries and fields of activity, will change in the future due to computerization (cf. Autor et al, 2003; Frey and Osborne, 2013; Bonin et al, 2015). Occupations with high substitution potential (cf. Dengler & Matthes, 2015, 2018, 2021; Kropp & Dengler, 2019) or jobs for which high demands are made in regard of digitalization are likely to be particularly affected. The past has shown that computers have substituted several jobs (Bessen, 2016). Due to the high share of less complex and specialized routine activities (often physical or manual) in the job, this would primarily affect workers on a low skill level and low-paid workers, but skilled workers would be also affected (cf. Dengler & Matthes, 2021; Dengler, 2016).¹ As a consequence, it can be assumed that there could be dynamic changes in occupations, skills, activities, requirements, and other economic effects. This probably could result in shifts within the employment structure, but also between or within occupational fields, industries and so on (cf. Zika et al, 2018; Weber, 2017).

Accordingly, employees will be challenged in the future to meet and master the technological changes as well as its effects on the labor market and the changing requirements in companies. Basically, it will be a matter of keeping job-related knowledge and skills up to date with the latest technological developments (cf. Dengler & Matthes, 2021; Acemoglu & Autor 2011). Employees may then have to demonstrate a greater willingness and ability to adapt by vocational education and training (VET) to be able to perform more complex activities that

¹ For further information about specific job changes through digital technologies in Germany see online tool ‘Job-Futuromat’ (Dengler et al, 2020), [online], <https://job-futuromat.iab.de/en/>.

are difficult to computerize, such as controlling and monitoring digitized work processes (cf. Trenerry et al, 2021; Harteis, 2019). At the same time, the educational stakeholders in vocational training are required to provide appropriate and suitable training provisions. Those should be used to develop the required skills and abilities with regard to dealing with new technologies. In addition, the training provisions will probably also have to be aimed increasingly at employees who, according to the Adult-Education-Survey Trend Report (Federal Ministry of Education and Research (BMBF), 2021), are relatively less likely to participate in VET, such as low-skilled and older employees or people with a migration background (cf. Siegfried & Berger, 2020). Moreover, in the course of digitalization, digital media will and should also be used through education at all levels to enable the use of new technologies not only in terms of content but also in practical terms.

In this context, serious games could be an effective tool, as they can convey learning content in a playful and motivating way. On the other hand, they can also evoke behavioral changes or simulate creative and interactive activities that are not subject to routine. They can also simulate complex real-life situations, such as the use of machines in non-routine situations, without disrupting operations. Apart from that, they enable personalized offers that can be adapted to the individual needs of the users and increase the learning motivation due to their playful character. Serious games could be used to develop the skills of the targeted employees at least to the level 5 of the German or European Qualifications Framework (DQR / EQF).

The practical problem is to find high-quality learning games for a specific job and skill level and finally to integrate them into an existing learning management system (LMS). The remaining of this paper presents the results of an in-depth analysis of classification systems for VET and a conceptual approach to use those classifications as well-defined terminology for search and retrieval of appropriate educational games.

2. Analysis of classification systems for vocational education and training

2.1 Starting point and current state of classifications

In Germany, classifications of occupations are used for statistics and analyses of the labor market or employment. Occupations or activities serve as an important indicator to classify employees and their position in the economy and society (cf. Federal Employment Agency [BA] 2020). In this context, the collected data are aggregated and classified in defined groups based on their similarity in terms of i.e. the main activity approach or other binding criteria (Dengler et al, 2014). Such a system of structured occupational data provides a detailed overview of comparable data to reflect the diversity of occupations and activities that is as close as possible to reality. In order to be able to investigate research questions in this regard, classification systems are developed that can be designed differently depending on the purpose of the survey (cf. Federal Statistical Office [Destatis], 2008). For this purpose, different systematics and classifications are presented and analyzed to identify a suitable occupational classification for this project.

2.2 Overview and results

An analyze of established and well-founded national and international classification systems is reported in this section. The research produced a total of four national and one international classification system (cf. Figure 1). Due to the small sample as a result of the literature search, an in-depth investigation of the classifications was undertaken. Therefore, the analysis is based on the following requirements: it should be a realistic and present representation of the diversity of occupations and activities in Germany, but it should give an adequate synopsis of occupational aggregates, there should be a link to the skill level and it should be compatible to international or other national classifications. The classifications presented partly build on each other but are often based on different structural principles. In addition, it should be considered, that they differ in the underlying definition of occupations and define different criteria for determining the similarity of activities or occupations.

| CLASSIFICATION | DESCRIPTION |
|--|--|
| International Standard Classification of Occupations (ISCO-08) (ILO, 2016) | <ul style="list-style-type: none"> • Four-level hierarchically structured classification with 10 major groups, 43 sub-major groups, 130 minor groups and 436 unit groups. • “Skill level” is the primary dimension used to arrange occupations into major groups, within each major group the dimension „skill specialization “ is used to arrange occupations into sub-levels. • Compatibility with the KldB 2010 via correspondence table, however, there are allocation problems, especially at the lowest levels (just approximation). • Internationally comparable occupational data, but no image of the real national labor market in Germany. • The major group level has proved to be not differentiated enough, sub-major group level is already too fine-grained. |
| German Classification of Occupations 2010 (KldB 2010) (BA, 2020) | <ul style="list-style-type: none"> • Five-level hierarchically structure classification with 10 occupational areas, 37 occupational main groups, 144 occupational groups, 702 occupational sub-groups, and 1,300 occupational types. • “Occupational / Skill specialization” (activities, knowledge, and skills) is the primary dimension used to arrange occupations on the first four levels of the classification. • The dimension “skill level” is used to arrange occupations on the last level, showing the complexity and range of tasks and duties to be performed in an occupation (similar to the ISCO-08). • The occupational types could be helpful for mappings according to the German or European Qualifications Framework (DQR/EQF), but with 1,300 positions the level is too detailed and fine-grained. • The dimension skill level could provide a starting point to identify occupations or jobs with main activity that are highly susceptible to computerization (those could have a particularly high need for digital and game-based learning opportunities). • Theory-based, uniform, up-to-date, realistic, national classification of occupations. • Comparability to the ISCO-08 and to previous national classifications (KldB 1975-1992) just via correspondence tables. • First level is no real occupational breakdown, but represents a thematic overview, with 37 positions the occupational main groups are already too fine-grained. |
| Occupational sectors and occupational segments (Matthes et al, 2015) | <ul style="list-style-type: none"> • Second-level hierarchically structure with 5 occupational sectors and 14 occupational segments. • Based on the second level of the KldB 2010 (aggregation of the 37 occupational main groups). • Using homogeneity analyses, the occupational main groups of the KldB 2010 (digit level 2) were arranged into occupational segments and sectors, on the basis of theoretical similarity of occupations to each other). • Each occupational segment includes a description of the main tasks and duties (not a standardized and verified procedure). • Further allocation dimension: number of employees dominating the labor market • Similar to the occupational field definition developed by the Federal Institute for Vocational Education and Training (BIBB). |
| Occupational fields of the Federal Institute for Vocational Education and Training (BIBB) (Tiemann, 2018; Tiemann et al, 2008) | <ul style="list-style-type: none"> • Third-level hierarchically structure with 3 occupational major fields, 12 or rather 20 occupational main fields and 50 occupational fields. • Using an identifier (linking the occupational groups [digit level 3] with the skill level [digit level 5] of the KldB 2010) to aggregate the occupations. • The primary dimension used to arrange occupations into groups is based on the similarity of main activity and industry focus (determined using microcensus and BIBB/BAuA employment survey). • Realistic and current structure: changes in occupations and activities are considered. • Verified, proved, long-term valid structure. • Compatibility with the concepts and occupational information in the KldB 2010; in addition, there is a reference back from the previous version of the occupational field definition in 2008 (that was based on the KldB 1992) to the development of the occupational main groups (digit level 2) in the KldB 2010. |
| German Classification of Economic Activities 2008 (WZ 2008) (Destatis, 2003, 2008, 2020) | <ul style="list-style-type: none"> • Multiple-level hierarchically structure with 21 sections, 88 divisions, 272 groups, 615 classes, 839 sub-classes. • The classification is based on the dimension main economic activity and products produced or services rendered by one or more business(es) or enterprises. • No occupational information, but classification based on industry or branch of business. • Can report changes, such as digitalization, in industries and economic structures. |

Figure 1: Overview of established and well-founded national and international classification systems

Based on a detailed analysis and discussion², the classification of the occupational fields, as defined by the BIBB (Tiemann, 2018), can be recommended as a result. As other reviewed classifications, it is based on a well-founded development and has been repeatedly empirical tested. The primary dimension used to classify the

² For a further discussion of the presented classification systems see “Review of classifications of occupations”, [online], <https://serious-games-berufliche-bildung.de/downloads/>.

occupations is based on the similarity of main activity and industry focus, which is determined using the statistical data collected by the annual microcensus³ and BIBB / BAuA⁴ Labor Force Surveys (ETB). Additionally, the developed occupational fields already reflect skill level, which describes the complexity of the activities to be performed. As the concept of the occupational fields is based on the KldB 2010, they are highly compatible and provide current specific occupational information from the expert database of the Federal Employment Agency. At the same time, the classification offers an acceptable and realistic overview of the national occupational structure of the German labor market, with 20 occupational main fields that present clearly defined content, and 50 more detailed occupational fields. Additionally, there is an international connection to the ISCO-08 and to other national classifications via correspondence tables. Thus, the BIBB classification best meets all requirements.

2.3 Detailed domain-specific academic debate

In addition to the summary of the overview presented above, this paragraph provides further domain-specific considerations about the review results, targeted for scientists in the educational sector.

In comparison, the national classification of occupations, KldB 2010 (BA, 2020), would be more suitable, as it presents the current occupational structure and realistically reflects developments on the labor market, as well as long-term changes over time. As the KldB 2010 is based on current occupational information from the expert database of the Federal Employment Agency, the classification is characterized by its practical relevance. At the same time, it is linked to ISCO-08 and thus compatible with international classifications, which is another important requirement. In the KldB 2010, the characteristic or dimension by which occupations are arranged into groups primarily is the dimension of skill specialization (activities, skills, and knowledge characterizing the occupation). Assuming that the increasing use of disruptive digital technologies will lead to changes in main activity within occupations and occupational fields, in particular, it could be useful to select a classification system that uses the main activity, for example. Also, regarding the determination of the VET profile and the associated self-location of interested people in their occupational field, the fitting criterion could be the main activity. Apart from that, the fifth level of the hierarchical structure of the KldB 2010, the dimension skill level, describes the complexity of the activities to be performed. This metadata could be used to determine the further vocational education and training profile of interested people: potential users could be located at their current qualification level, e.g., by asking for information on the qualification or skill level.

But a difficulty of the KldB 2010 could be the fact that the first hierarchical level, the occupational areas (digit level 1), provides more of a thematic overview. Therefore, it is intended to guarantee user-friendly handling of the classification than to correspond to the realistic occupational breakdown. In contrast, the second level, the occupational main groups (digit level 2) with 37 elements, is too detailed for the purpose of maintaining a moderate overview. In this context, the occupational segments and occupational sectors could be the better choice, as they are based on the KldB 2010, but provide 14 relatively clearly defined occupational aggregates (cf. Matthes et al, 2015). But in a closer comparison, the occupational fields or occupational main fields as defined by the BIBB would be more suitable. Those are also used in the QuBe project of the Federal Institute for Vocational Education and Training (BIBB) and the Institute for Labor Market and Career Research (IAB) to provide a long-term overview of the likely development of labor demand and supply in terms of qualifications and occupations.

Similar to the QuBe project⁵, the SG4BB project will also identify users according to qualifications and occupations in order to locate them in their occupational field. For this purpose, the concept of identifiers has used that link the occupational groups [digit level 3] with the skill level [digit level 5] of the KldB 2010. Based on this concept occupations are aggregated according to their main activities. Therefore, the developed occupational fields already reflect skill level, but at the same time offer an acceptable overview with 20 occupational main fields with clearly defined content and 50 more detailed occupational fields. The dimension used to classify the occupations is based on the main activity defined by the microcensus and ETB. Like the occupational segments and sectors, the updated version of the occupational fields is based on the KldB 2010. Also, the microcensus and the ETB use the KldB 2010, which demonstrates high compatibility with national and international classifications.

³ URL: https://www.it.nrw/sites/default/files/atoms/files/mz-fragebogen_2019_g_muster_englisch.pdf (last visited on 22nd June 2022).

⁴ German Federal Institute for Occupational Safety and Health (BAuA)

⁵ URL: <https://www.bibb.de/en/11727.php> (last visited on 22nd June 2022).

3. Conceptual approach towards a search engine for vocational education and training

3.1 Occupational fields as classification system for vocational education and training

From the educational perspective, the conceptual approach is based on the determination of a vocational training profile. Finally, a construct of three interrelated components has been elaborated, with respect to the definition of well-defined, machine-readable attribute lists for a search engine: occupational main fields, occupational fields and main activities (cf. Figure 2).

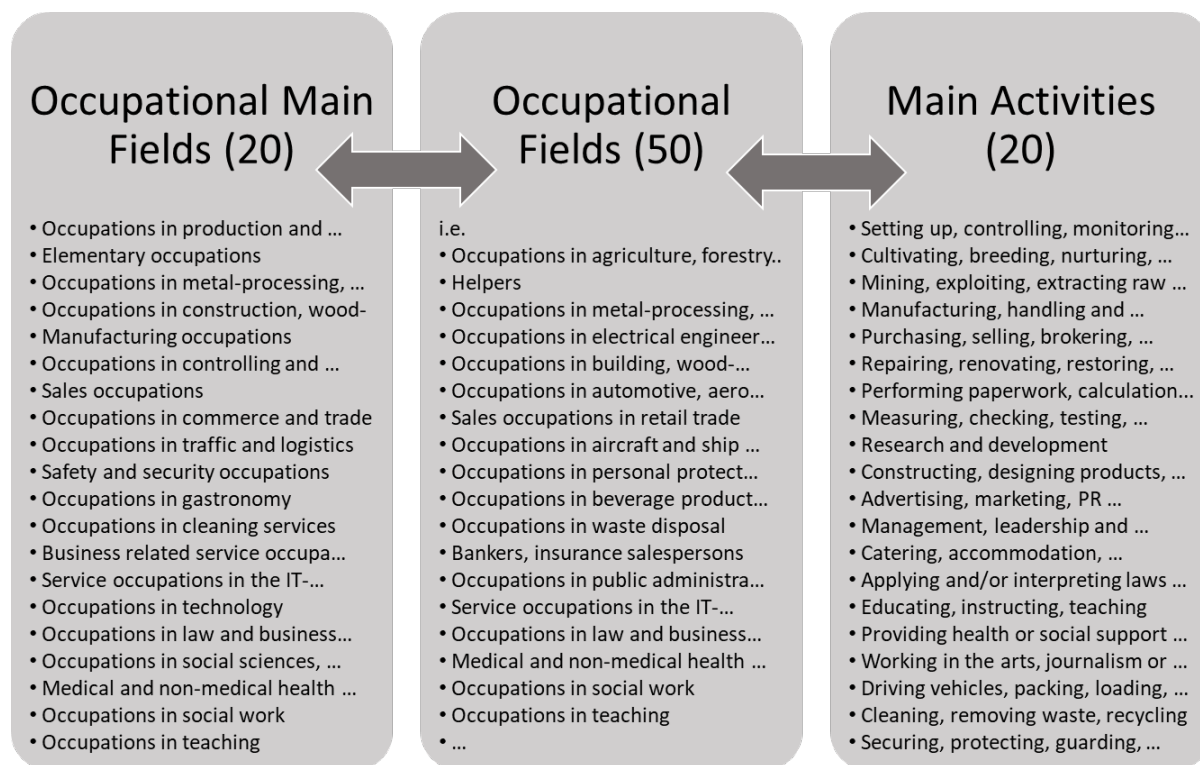


Figure 2: Interrelated components based on the classification of occupations

Based on the analysis of classification systems, the interrelation among occupational (main) fields, and main activities become obvious: the 50 occupational fields are grouped together in further 20 occupational main fields; thus, they present a manageable and practical overview of the national labor market. In turn, each occupational field is explicitly assigned to one of the 20 main activities and corresponding skill level. This enables interested people (or other educational stakeholders) to locate themselves in their individual occupational field and at the same time at their skill level and in their occupational main activity.

Technically speaking, the classification of occupations (Figure 2) and the matrix structure among occupational fields and educational games (Figure 3) allows search and retrieval of appropriate games for occupational fields: In the authoring phase, providers of educational games need to attribute the games with occupational fields and main fields. During the search and retrieval phase, the games can be identified by potential users using the search engine for VET (see next section) and occupational (main) fields and activities as search criteria. Hereby it needs to be stated that some games are fully dedicated to a particular occupational field and industrial focus (e.g. the 'Corrugated Service Game' tackling specific processes and machines for corrugated paper and boards), whereas other games such as the 'IT Security Game' covers more general topics and can be used in a broad range of occupational fields.

| Occupational Main Fields | Occupational Fields | Games | Corrugated Service Game | IT Security Game | Game unknown | ... |
|------------------------------------|--|-------|-------------------------|------------------|--------------|-----|
| IT and scientific occupations | ... | | | X | | |
| Technical occupations | Technicians | | X | X | | |
| | Technical draughtsmen/draughtswomen, related occupations | | | X | | |
| | Surveying and mapping | | | X | | |
| | Specialist skilled technicians | | X | X | | |
| Legal, management and economic ... | ... | | | X | | |
| Healthcare occupations | | | | X | | |
| Social occupations | | | | X | | |
| Teaching occupations | | | | X | | |

Figure 3: Matrix for occupational (main) fields and educational games

3.2 Search Engine for educational games for vocational education and training

The Serious Games Information Center (SG-IC) ⁶ offers a web portal for search and retrieval of serious games and educational games as a main application field of serious games (cf. Göbel et al., 2018). Game developers and publishers can use the SG-IC to describe their games. Vice versa, educators such as teachers, coaches or trainers and individual learners can use the portal to find appropriate educational games for their educational purposes and learning goals. The underlying semantic basis for search and retrieval is built by the so-called Serious Games Metadata-Format (SG-MDF), which has been published as DIN SPEC 91380 by the German body for standardization (DIN institute) and is available for free in electronic form via the Beuth publisher.⁷ The SG-MDF and, subsequently, the SG-IC as search engine using the SG-MDF already offers an application profile for educational games, but that profile is not focused on vocational education and training and misses the well-defined terminology and classifications of occupations typically used in that application domain.



Figure 4: SG4BB pipe

For that, the public funded project “SG4BB – Serious Games for Vocational Education and Training” has been established with the overall aim to provide a platform for the use of serious games / educational games in VET. Figure 4 illustrates the process pipeline for the usage of the SG4BB platform: In a first step, learning providers, coaches or individual learners are seeking for appropriate learning material for a specific job / occupation. They can use the SG-IC metadata-based information system to formulate queries for serious games / educational games as game-based learning material. As search criteria, among other filters for specific occupational fields, main activities, a target age group or a game genre can be defined. As a result of the information retrieval process, a set of candidates (i.e. appropriate educational games, matching the search criteria of the formulated query) are listed in the SG-IC and can be analyzed in a detail view which provides all available metadata

⁶ The SG-IC is a classical web-based information system in form of a portal. URL: <https://seriousgames-portal.org> (last visited on 17th June 2022).

⁷ URL: <https://www.beuth.de/en/technical-rule/din-spec-91380/289947896> (last visited on 3rd June 2022).

information (following the standardized SG-MDF format) for an educational game / serious game. Within the distribution section of the SG-MDF, users get information where the original games are available. Hence, users can follow the links and directly access the games via available download platforms, and integrate it within their learning environment (i.e. typically a learning management system). In SG4BB, by example, an interface between the SG-IC and the “Skillfire” platform – as “Steam-like” distribution platform for game-based learning and training material – has been built. Finally, as soon as the serious games / educational games have been used, the users / learners are invited to provide their (individual, subjective) feedback about a game and share it with the SG4BB open community. In the following parts this paper focuses on the first and second step of the pipeline. The development process of a middleware for the integration of educational games into existing LMS (such as moodle in SG4BB) as well as the data exchange and communication between the educational games and the LMS (based on the xAPI standard) are part of ongoing work in the SG4BB project and will be described in further research contributions.

3.3 Metadata-based application profile for vocational education and training

The SG-MDF (Göbel et al, 2011; 2018) as standardized description format (DIN SPEC 91380) for serious games provides a hierarchical “level” concept: Level 1 represents the “core” level with a set of mandatory descriptive metadata fields which are relevant for all domains and subdomains of serious games, among others education, training and simulation, health, marketing or awareness games. Level 2 provides additional optional metadata fields, also applicable for any serious games’ application domain. Level 3 has been conceptualized for so-called “application profiles” providing additional metadata information fields relevant for specific application fields. In the available document of the SG-MDF two application profiles are already available: a profile for “education” and a profile for “health”. Based on the application profile for educational games, within the context of the SG4BB project, another more detailed profile for vocational education and training has been elaborated. This profile provides metadata fields and pre-defined attribute lists for the specification of the characterizing goal of games for vocational training as well as the occupational (main) fields and main activities (cf. Figure 2). Those attribute lists with its well-defined terminology / classification systems support the information retrieval process to find appropriate educational games matching the needs of users / learners respectively learning providers.

3.4 Search Engine for educational games for vocational education and training

In a second step, the existing SG-IC has been extended according to the application profile for vocational training. This includes the extension of a metadata editor on the authoring side, enabling developers and publishers to describe their games based on the SG-MDF, and the extension of the search filters considering the attribute lists and classifications of occupations within the search process. More concrete, the new search filters include “vocational education and training” as one of the pre-defined application fields and all the occupation fields as possible search categories / keywords for application fields. These filter criteria are combined with any other keywords provided by users. As a result of the search process, users get a list of candidates / games matching the search parameters (cf. Figure 5a on the left side with two candidates). Based on the list of candidates, users can select the candidates and get a detailed view / metadata description of the game structured according to the SG-MDF (cf. example for the security game “Go Online” in Figure 5b).

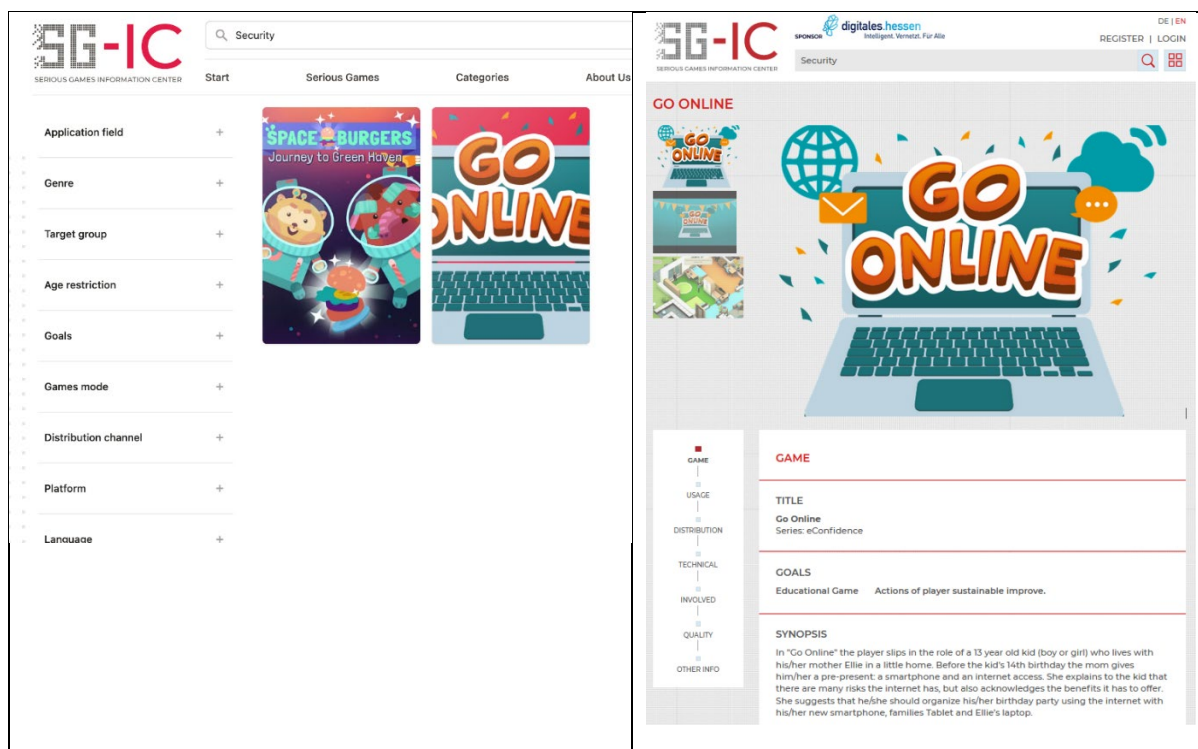


Figure 5: SG-IC portal search form with filters and keyword search (left) and a detailed view / metadata description of a specific game following the structure of the SG-MDF (right).

4. Conclusions

This paper presents a conceptual approach and practical solution in form of a metadata-based information / catalogue system to find appropriate serious games /educational games for (continuing) vocational education and training. On the conceptual side, a literature review has been undertaken to identify a classification of occupations that can be used as a database and fitting criterion to find and provide appropriate serious games / educational games in vocational education and training. A set of three interrelated classification fields has been identified: Occupational fields and occupational main fields plus main activities (relevant for the different occupational fields) (Tiemann, 2018). On the technical side, those classifications have been integrated into the SG-MDF as application profile “vocational education and training” and subsequently are used for the description and retrieval of games within the SG-IC. Therefore, the categories have to be precise, so the authors will be able to interpret them.

The elaborated concepts and its practical implementation are going to be tested within the SG4BB research project and will be available for the public starting in September 2022. Next steps will include the development of a middleware to download and integrate available educational games into learning environments (LMS). Hereby, the middleware will provide mechanisms for real-time communication among the games and LMS. On a second strand, the quality of educational games for vocational education and training will be analyzed according to quality criteria (Caserman et al., 2020). The results of those game studies will end in and further enhance the SG-MDF and SG-IC allowing potential users a better qualitative assessment of available learning appliances and will support their decision which one will be bought / licensed and integrated into a LMS.

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