Research in Engineering Education Symposium &
Australasian Association for Engineering Education Conference
5 – 8 December, 2021 - Perth, WA

Design Principles for Auto-mapping Professional Competencies

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ABSTRACT

CONTEXT

Engineers are required to maintain currency in their respective fields (through continuous professional development). In Australia, engineering students are expected to progress towards Engineers Australia's (EA) Stage 1 competencies throughout the course of their accredited engineering studies. Similarly, professional frameworks are well established internationally and recognised as key guide for the development of engineers in the workforce (Leslie, 2016). Throughout their professional careers, engineers are required to undergo formal, informal, and non-formal learning. The process of maintaining these records and mapping them to competency standards is rigorous and time consuming. This paper examines how this process is undertaken and investigate how this process can be automated to facilitate the alignment between education and industry needs.

PURPOSE OR GOAL

To provide the design principles of auto-mapping professional competencies, this research effort will apply the business process analytics methodology. This methodology will assist in identifying the inefficiencies of the current mapping process. By doing so, it will be possible to identify a new automated process that can facilitate the design of new software. This technology will assist both student and practicing engineers alike by providing correct mapping to competency frameworks and alleviating the time burden to do so. This system will also eradicate some of the administrative functions performed by professional bodies and their competency assessors.

APPROACH OR METHODOLOGY/METHODS

By applying the business process analytics approach to a series of case studies and an extensive literature review, the process of how mapping of skills and competencies to formal qualifications is presented. The paper identifies areas of inefficiencies and propose design principles and processes for an automated software solution.

ACTUAL OR ANTICIPATED OUTCOMES

The outcome of this research is a set of design principles that can be used to map competencies utilising an automated software solution. These design principles will inform the development of the system by providing a clear picture of what users are involved and the critical data that needs to be shared between them. The development of an automated solution to map different forms of learning to professional skills strengthen the connection between formal qualifications, continuous development, and professional competencies.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

This study discusses the importance of mapping learning against skills in standard competency frameworks during formal engineering education and throughout professional life and sets the principles to conduct an automatic mapping to facilitate the development, achievement, and recognition of engineering standard competencies.

KEYWORDS

Continuous professional development, micro-credentials, professional skills, competencies, auto-mapping, life-long learning, learning technology.

Introduction

Professionals, such as engineers, curate a portfolio of their learnings and experiences. A professional portfolio logs the skills and competencies of a professional from formal qualifications and extends with lifelong learning. By applying the business process analytics, an established methodology that seeks to understand business processes with a view of improving effectiveness and efficiencies, this paper will analyse the processes of how a professional currently maintains their records of competencies. These records, sometimes referred to as Continuous Professional Development (CPD) journal, are used for a myriad of reasons including, career goal setting and measuring, Curriculum Vitae and as evidence of maintaining currency to be produced for audit by an industry body.

Many professions require their practitioners to undergo regular audit, either as a regulatory requirement or as a requirement for society membership. As an example, Engineers Australia (EA) are one such industry body that has a rigorous auditing policy for their membership. This auditing process will also be analysed with the business process analytics approach. By doing so, this paper will be able to analyse and identify the full cycle of recording a professional's skills and competencies.

By applying the business process analytics approach to a series of case studies and an extensive literature review, the process to map skills and competencies to formal qualifications come to light. Current formal qualifications list learning outcomes in terms of knowledge, skills, and the application of knowledge and skills. However, formal academic programs are structured in units of study with a range of learning outcomes. The assessment is conducted overall for the whole unit, often not grading the achievement of each individual learning outcome. Students can pass the unit with 50% of marks, without indication of what 50% they have not mastered. Boud&Jorre de St Jorre reflect on that in a recent paper (Boud & Jorre de St Jorre, 2021).

Qualifications are meant to show employers and others what the holder is capable of and has achieved (Noonan et al., 2019). However, the graduation documentation does not provide enough clarity and transparency. The award testifies the completion of the formal qualification, the testamur lists the units of study with the overall student's grade for each, and the Australian Higher Education Graduation Statement (AHEGS) describes extracurricular activities.

Competency based frameworks and assessment provide a common language to translate learnings in formal education to industry expectations (Connors et al 2018). In Australia, for example, EA provides competency standards for different degrees and levels of experience in the engineering profession. Although research has been developed in the Australian context, the findings are general and applicable to other competency frameworks, recognised internationally (Leslie, 2016).

The mapping continues to be necessary after graduation, for Continuous Professional Development. This paper explores three case studies. The first relates to an engineering student during or just graduated their degree. The second case study explores the practicing professional undertaking life-long learning. The final case study relates to the auditing process of a professional.

Finally, by understanding how the process is currently being undertaken, this paper will provide design principles that can be used by a software development team to implement into an automated solution.

Mapping learning to competency frameworks – Case Studies

To ascertain how professionals currently map their learnings to competencies frameworks, this paper will use the case study method. This method is used to "*closely examine the data within a specific context*" (Zainal, 2017). The data which we need to ascertain is the process of how

the mapping of competencies are currently being performed, as such, this paper will examine three separate case studies. The current mapping methods are analysed from Case study 1: Formal Education and Case study 2: Informal Learning. These two cases provide examples of how a professional currently map their skills and competencies. Finally, Case study 3: Peer Review and Audit is provided to inform the current process of auditing/peer reviewing a professional and their CPD journals. All three case studies have been adapted from the Skills Framework for the Information Age (SFIA) Self-Assessment Guidelines (SFIA-Foundation) and Writing Engineering Competency Claims (Engineers-Australia) to provide a 'high-level' and generic view of the processes performed.

Case 1: Formal Education

When a student undergoes a formal education, such as a bachelor's degree, the competencies that they learn are usually itemised for them. These programs are broken down into individualised units of study which in turn contain a mapping of competencies to standard frameworks. For example, in Australia, professional engineering degrees are accredited by EA and mapped against entry to profession competency standards (EA's Stage 1 competencies). In the effort to map and log these competencies into their CPD journals, the student must gather these itemised competencies and map them to their respective frameworks.

Within a four-year degree, there are numerous units of study (subjects), each with their own learning outcomes and list of competencies to map. The list of entries is large. When a student reaches the skills and competencies, the student then manually transfers these items into a journal, often in the form of a matrix or spreadsheet. The process undertaken to map these is as follows:

- ↳ Create a professional CPD (Continuous Professional Development) journal
- ↳ Find the unit of study and their attributed competencies
- ↳ Find the listing of the skills and competencies
- ↳ Individually copy and paste, or manually type in the skill or competency into the journal
- ↳ Date each entry and provide additional details surrounding the study including:
    - Where the unit was undertaken
    - The name of the unit
    - The learning outcomes for the unit
    - Duration of the activity (hours)
- ↳ Perform the above process for each of the skill and competencies for each of the frameworks targeted by the professional

Case 2: Informal Learning

Professional practitioners are required to undergo continuous professional development (CPD) for several reasons; to maintain currency of knowledge, maintain employability or as a requirement of membership of an industry society. For example, EA require their members to perform one hundred and fifty hours of professional development in a three-year cycle (*Continuing Professional Development* | *CPD* | *Engineers Australia*, n.d.). Such learning activities can include formal learning like Case 1, however, there are also many other types of learning that a professional undergoes. This can include reading journal articles, technical documentation, attending a conference and many more activities. Unlike Case 1, these do not come pre-mapped to any specific skill or competency. The onus is on the professional to figure out where to journal the activity. This may be simple for some frameworks; they read an article for an hour and can simply state that. However, some frameworks like the Skills Framework for the Information Age (SFIA) will require additional effort to map to. If a software engineer reads this paper, to which skill or skills of the many skills in that framework would they map the activity? To map these skills correctly requires additional training for the professional in how to recognise the skills being developed by the article and which skill(s) is the most appropriate to claim.

Below is the process of mapping this paper to the SFIA:

- ↳ Undergo learning activity
- ↳ Identify the pertinent skills as per SFIA within the article
- ↳ Create a new entry in the CPD journal
- ↳ Itemise the particulars of the paper
    - Authors
    - Journal
    - Date
    - Overall learning of the paper
- ↳ Itemise the skills being learned/strengthened

Case 3: Peer Review and Audit

Many industry bodies require their members to undergo regular audit and peer review. For example, EA require their charted engineers to undergo a minimum of 150 hours of professional development and these professionals are audited and peer reviewed to maintain industry standards. In general terms, this process is twofold. There is an administrative audit and a peer review. The peer review is conducted by fellow members of the industry body. The purpose of this is to seek peer acceptance of a professional's competence, attitude, and professionalism. The administrative audit, however, is a bureaucratic process. A professional is required to articulate and present a report detailing their profession, a statement of competence and a journal of their lifelong learning (CPD).

Although there are good reasons to keep peer reviews of a professional by the industry bodies, automation can assist in lighting the administrative burden of the audit. As such, the following (generic) process is observed:

- ↳ Professional to write a professional practice report which include the competencies claimed
- ↳ Reflective practice report
- ↳ Panel interview
- ↳ National assessor to confirm

Online Tools:

Many professional bodies and societies now have online solutions to assist their members with the task of recording their CPD activities. This involves the professional to log into the respective portal, and manually filling in the provided forms or spreadsheets. Except for some analytics and report creation, the process is still very similar to the above cases.

Methodology

Business process analytics can provide a unique perspective when we apply this methodology to the above three case studies. Business process analytics "*is a methodology for the analysis of a business with a view to understanding the processes and improving the efficiency and effectiveness of its operations*" (Business Process Analysis, 2012).

By applying the Business Process Analytics methodology, the efficacy of the respective processes come to light. The first step in this methodology is to develop a full understanding of the entire context of operation. The context here is a professional, once leaving school, undertakes a University Degree, enters the workforce, continues to learn via additional formal courses, informal learnings, and additional activities. The professional then must map these learning activities to the standards of their industry bodies and undergo regular audits to confirm the professional's competence is current and acceptable for their profession.

Analysing these processes, there are several inefficiencies that can be immediately identified. These include the following:

1. Skills and competencies are not transferred when a formal qualification is awarded

   In Case 1, when the student successfully passes a unit of study or even the entire degree program, the skills and competencies that are already mapped for them are static. They are mapped and electronically stored, but they don't transfer to the student's record or journal. As these activities are already mapped according to the respective frameworks, a software solution could be implemented to transfer this information to the student and digitally stored.
2. The professional may not know how to map the skill or competence to their respective frameworks

   Some skill or competency frameworks can be quite complex, and it is not unreasonable to infer that this complexity provides a disincentive for the professional to be proactive in their journaling of their skills and competencies. This can be addressed by automating this process as mentioned above.
3. The process is quite repetitive in nature.

   When a professional undertakes regular professional development activities, they may spend just the same amount of time journaling their learning activities as they are learning.
4. How many frameworks does the professional need to comply to?

   As seen in Case 1, a learning activity can be accredited by more than one framework. Not to mention that the professional may also be engaged with additional industry societies that may also recognise the learning activity, but the activity hasn't been accredited by their framework. What data must the professional keep and what data can they ignore? A proactive professional who is engaged with multiple industry bodies must endure an exponential growth in complexity that they must navigate to maintain membership and accreditation.
5. Auditing a CPD journal is a lengthy process

   Auditing a journal is a manual and very time-consuming task. As indicated in Case 3, when a peer is conducting an audit, they not only offer a peer review as to the standards of their profession, but the process also requires a high level of administrative encumbrance. This burden is met by applying additional labour at the problem. This is a cost of time and money for all stakeholders involved.

The inefficiencies listed above may be perceived as a disincentive proactive journaling one's professional development. Some professionals may even be disengaged with CPD activities altogether, simply because of the administrative burden.

Data Management

Analysing the key findings above, data management is identified as the key factor that leads to inefficiency in the process. Each stakeholder has access to the data that they require, however, this data is not transferred efficiently. A university may have their programs mapped to a competency framework, but this information is not available on any transcript or in any digital form that is of use for this process. Even the competency frameworks themselves do not have their data available to effectively assist a professional. Some information is available as an online resource, and many have online tools to assist, however many professionals belong to multiple industry bodies, thus fragmenting their efforts to maintain a cohesive CPD journal and professional portfolio.

Current Attempts to Address These Issues

Some initiatives have emerged in recent times to address aspects of this issue. Such as micro-credentials and online repositories.

Micro-credentials

According to Beverly Oliver a micro-credential is "*A certification of assessed learning that is additional, alternate, complementary to or a formal component of a formal qualification"* (Oliver, 2019). This provides a very powerful tool to allow for many different learning activities to be recognised by formal qualification frameworks. Oliver's credential taxonomy can be observed in practice at Deakin University (https://credentials.deakin.edu.au/). It is quite similar in nature to how EA recognises different learning activities, but Oliver's definition of micro-credentials has a strong emphasis on assessed learnings. It is the assessment that is fundamental to the micro-credential. Once a student passes the assessment, they are awarded the micro-credential, which in turn could be mapped to a formal qualification. The micro-credentialing paradigm provides an avenue for formal recognition of learnings, complementing formal qualifications. The need remains for a system that is primarily aligned with industry competency frameworks.

Online Repositories and Services

Online repositories of qualifications and credentials have been in service for several years now. One such service is (https://www.myequals.edu.au/). MyEquals is an online service that provides online access to certified official academic transcripts. This service, utilised by Australian and New Zealand educational institutions, maintains student's official transcripts, and provides these transcripts electronically utilising a myriad or security measures. This service allows students to log in and download official transcripts anytime. This is a useful service if one has lost their transcripts or requires forwarding one to potential employers. However, the mapping of the individual skills or competencies learned during those activities, is not addressed.

Another similar service is Accredible (https://www.accredible.com/). Unlike MyEquals, Accredible does not focus on formal qualifications but on badges. Accreddible states that a badge is "*a symbol or indicator of an accomplishment, skill, quality or interest*" (Digital Badges with Accredible, 2019). Accredible boasts an impressive list of both academic and industry clients. Their badges provide additional security features to protect against any attempts of fraudulent claims. Although their service does provide an ability to list skills and competencies that was required to earn a badge, the professional will still need to perform the before mentioned processes to map these to their CPD journals.

World Education Service

The World Education Service (WES) (https://www.wes.org/). is a service that provides validation of qualifications between jurisdictions. Should a professional travel to work internationally, WES provides a service that will validate their qualifications. This is usually done at the expense of the professional but offers to add a level of security and trust that the professional's claim of qualification is legitimate. WES has also adopted additional technologies to facilitate this process including blockchain technology. However, as the service offered by WES is strictly related to authenticating certifications and qualifications, the mapping issue prevails.

Design Principles for Auto-mapping Competencies

By identifying that data management is a major concern when attempting to map competencies, a software solution to automate the mapping process is proposed. As this will be an information system that involves users and artifacts(data), this paper chose to utilise design principles as highlighted by (Gregor et al., 2020). Their Design Principles in Research Practice and Information Systems have identified three categories of design principles, the third of which will be deployed here (Design principles about user activity and artifacts). This design principle asserts that a system should have features of X that perform functions of Y that allow the user to perform Z task(s). Within this context, a system will be required to be

online (X), that will be automated (Y), and allow the user (or in this instance, not require the user to) map the competencies to their CPD journals.

The above example is provided as an abstract example, as the full context of mapping competencies involve more users and artefacts that just the professional and a competency. To facilitate an automated system, this paper has identified the need for five users (stakeholders in business terms) and two artefacts, described below:

Users (Stakeholders)

Professional

Within the context of this solution, the Professional is an individual who undertakes learning activities. As many frameworks also allow for formal, informal, and non-formal learnings as part of their CPD activities, the Professional also needs to have the ability to fulfil a Credential. This will help facilitate the mapping for Case 2. For example, if they participate in an informal learning activity, this activity is not pre-mapped, thus the Professional will need to utilise the same automapping solution.

Provider

A provider is an organisation or contractor of a learning activity, such as an educational institution or training provider. The provider is responsible for entering the required data into the Credential and issuing (forwarding) the Credential. This process itself can be automated through the providers Customer Management System (CMS). The provider may also provide learning activities that are mapped to multiple frameworks, like Case 1. Remembering that the Credential is templated by the Framework Entity, the Provider will need to utilise a single Credential from all frameworks required.

Framework Entity

The Framework Entity is the stakeholder that maintains a skill or competency framework. It is their responsibility to provide several ‘templates’ to be utilised by other users. The first template is the Credential itself. This Credential contains information on what framework it is from and a list of competencies that the credential can award. The second template is a template for the line entry in the professionals CPD journal, a Line Item. This template will enforce consistency and will ensure that all requirements of the professional to record, are recorded. As the framework entity constructs both credential and line item, the administrative burden of auditing is reduced.

Credential Host

The Credential Host provides a service to store, and provides access to, the Credential online. Very similar to the online repositories already available. Under this new process, the existing Credential Hosts will need to be augmented to facilitate the forwarding of the credential to the Portfolio Host. If there are more than one Credential Host, the Professional is required to nominate a ‘primary’ host. The required functions will be performed by the primary host. This includes providing the Credential particulars viewable online, should anyone follow the links from a Professionals portfolio.

Portfolio Host

The Portfolio Host is responsible for providing an online portal to the professional’s portfolio as well as public viewership. When the Portfolio Host receives a Credential, the Credential is interrogated to ascertain which framework it belongs to. Once this is established, the Portfolio Host will request a Line-Item template (if this is the first line entry, otherwise the template will be used from a previous mapping request). Once this new Line Item is created, the data for that line is completed by matching the data in the Credential to the fields in the Line Item. If the Portfolio host receives multiple (a list of) Credentials, this process is repeated until all Credentials are exhausted.

Critical Data structures (Artefacts)

There are two critical data structures that will need to be implemented. As discussed, the Credential will be required to contain all the information about the learning activity. A concept of a Line Item is also required. This will contain all the information requirements, as mandated by the Framework Entity.

Credential

Within the context of this solution, a credential is a data structure that is created by the Framework Entity and used by a Provider and the Professional. Once the requirement of the Credential is completed, the provider or the Professional will forward the Credential to the Credential Host for storage and so forth.

The components of this data structure are critical for the automapping solution. It is the Credential that contains all the data that a Framework Entity requires for CPD journaling. And as indicated in Case 1, an activity can contain skills and competencies for multiple Frameworks. Thus, multiple Credentials will need to be fulfilled, One for each Framework.

Line Item

A Line Item is simply a single entry into a Professionals CPD journal. These commonly contain the date the activity was completed, what the learning outcomes were, how long the activity was etc. However, there may be certain particulars that a Framework Entity may require that is unique to their industry or professional body. Thus, the template for the Line Item is to be mandated by the Framework Entity. Upon adopting this solution, the framework Entity will be required to construct both Credential and Line Item and ensure that the data contained in the Credential 'fits' the fields in the Line item is also required.

To connect the above users and artefacts together into a single cohesive system, the following process is required:

- ↳ Professional completes a learning activity, either self-directed or as a student of a provider.
- ↳ The Framework Entity sends a Credential template that provides fields for the required information.
- ↳ If there is a provider, their customer management system will automatically complete the Credential requirements. If the activity is a self-directed activity that does not have an automapping feature, the professional will complete this requirement.
- ↳ The completed Credential is then forwarded to the Credential Host, to be permanently stored. If there is more than one Credential Host, a primary host is nominated by the professional.
- ↳ The Primary Credential Host then forwards the Credential to the Portfolio Host.
- ↳ The Portfolio Host then requests and receives a Line Item from the Framework Entity.
- ↳ The Portfolio Host then marries the data from the Credential to the required fields in the Line Item
- ↳ The completed Line Item is then journaled in the professionals CPD journal and is available for display

Conclusion

There has been a proliferation of courses and education offerings to seek to keep education up to date with the current industry needs and societal trends. Unfortunately, with this proliferation, education, training, and other learnings have become an enormous ecosystem each one competing with the other. This makes the context confusing to the professional. Such a fragmented environment is complex to navigate without a solution that guides with their choices for career building and professional development.

Analysing this issue through the lens of business process analytics, this paper has identified the current process of transferring, mapping, and storing data to be the main concern. The primary inefficiency is the manual nature in which these tasks are currently performed. By

utilising current technologies, many of the tasks required to map and record learnings can be automated. By deploying the user activity and artefacts design principles, the required users and data have been identified and the process of how these interact with each other has been developed. The proposed design principles can inform the development of an automapping solution. An auto-mapping solution has the potential to facilitate the development, achievement and recognition of engineering standard competencies.

Future Works

As part of an ongoing research effort, the next step is to demonstrate the use of these design principles with practical real-world examples. This will be accomplished in consult with members of the Engineers Australia assessment team. This step will allow the research team to demonstrate the effectiveness of the design principles as well as provide empirical evidence for the engineering educators to interrogate.

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