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Exploration of Learning Gained Through CoderDojo Coding Activities

Irene Sheridan
Extended Campus, Cork Institute of Technology, Cork, Ireland, irene.sheridan@cit.ie

Deirdre Goggin
Extended Campus, Cork Institute of Technology, Cork, Ireland, deirdre.goggin@cit.ie

Linda O'Sullivan
Department of Computing, Cork Institute of Technology, linda.osullivan@cit.ie

EXPLORATION OF LEARNING GAINED THROUGH CODERDOJO CODING ACTIVITIES

Irene Sheridan[1], Deirdre Goggin[2], Linda O'Sullivan[3]

[1, 2]CIT Extended Campus, Cork Institute of Technology (IRELAND)
[3]Department of Computing, Cork Institute of Technology (IRELAND)

Abstract

In an increasingly digital world there is a considerable and growing divide between those who are considered to be digitally literate and those who are not. In addition, among those who are digitally literate, there is a divide between those capable of engaging with technology end products and applications as competent users and those capable of developing software themselves; between users and creators. As technology becomes more pervasive in our society it has impacts in most aspects of life, including education, health, culture and work. In terms of the workplace impact it is clear that the currently reported skills deficits, gaps and mismatches are generating significant demand for skilled information technology workers across many sectors and the ability to meet this demand can have substantial impact on economic development.

Developing appropriate technological skills and competence among young people has been the focus of many government, industry-led and voluntary schemes and has given rise to a diverse set of initiatives around Europe. However, little has been published on the attainment of knowledge, skill, competence and evidence of learning outcomes through these initiatives. This research has focused on the efforts to support development of coding capability among young people through the CoderDojo voluntary initiative and sought to identify the skills which are potentially transferable in an education and workplace context. CoderDojo is a global movement of free, volunteer-led, community based programming clubs for young people between the ages of seven and seventeen. The movement was founded by James Whelton and Bill Liao, an entrepreneur and philanthropist. From the first Dojo founded in Cork in Ireland in 2011, the movement has grown significantly and by May 2015 there were over 675 verified Dojos in 57 countries globally [1]. Through a review of the extant literature and the development of a potential skills acquisition template, this research seeks to identify and evaluate the knowledge, skills and competence that may be developed by participants in the CoderDojo movement. Before seeking to identify the skills that might be attained through programming activities, consideration of the broad themes and language of digital skills attainment is presented. The actual skills that are attained are considered in relation to the context within which the learning takes place. A research instrument is developed in association with project collaborators in the CoderDojo volunteer coding movement. The findings from the research are analysed and some preliminary recommendations are considered.

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Keywords: Digital skills, recognition of learning, coding.

1 DIGITAL SKILLS AND DIGITAL LITERACY

In considering the importance of digital skills and abilities, Prensky claims that:

> …*the single skill that will, above all others, distinguish a literate person is programming literacy, the ability to make digital technology do whatever, within the possible one wants it to do -- to bend digital technology to one's needs, purposes, and will, just as in the present we bend words and images. Some call this skill human-machine interaction; some call it procedural literacy. Others just call it programming* [2].

While much is written on the subject of digital literacy there is no generally agreed definition. Li and Ranieri point out that when Gilster first used the term 'digital literacy' it was defined as 'the ability to understand and use information in multiple formats from a wide range of courses when it is presented via computers' [3] [4]. In more recent times Stordy reports 685 publications over three years relating to literacy and digital technologies, stressing different concepts and highlighting 35 different types of literacy [5]. Considering literacy as both a personal evidenced cognitive ability and a social constructed practice, Stordy goes on to propose that digital literacies can be thought of as:

> *…the abilities a person or social group draws upon when interacting with digital technologies to derive or produce meaning, and the social, learning and work-related practices that these abilities are applied to*. [5, p. 172].

This consideration of the context or the application setting aligns well with the ECDL Foundation's view that a person's required and evidenced digital proficiency relates to the context in which it is to be applied, is subjective and sits within an evolving technological landscape [6]. The changing landscape and the evolution of technology itself presents difficulties in terms of the static definition of literacy and competence levels. In their working document the European Commission relates the concepts of literacy and competence by defining digital literacy as

> *the skills required to achieve digital competence, the confident and critical use of ICT for work leisure, learning and communication*… and notes that it is …*underpinned by basic technical use of computers and the internet* [7].

The recommendations of the working document include the closer linking of digital literacy with media literacy through the EU Media Literacy Charter.

The ECDL Foundation suggests a framework illustrated in Fig. 1 below in which digital proficiency progresses through awareness, literacy, competence and expertise and goes on to suggest that while literacy is required for social interactions; competence and expertise tend to relate to particular workplace settings and job roles.

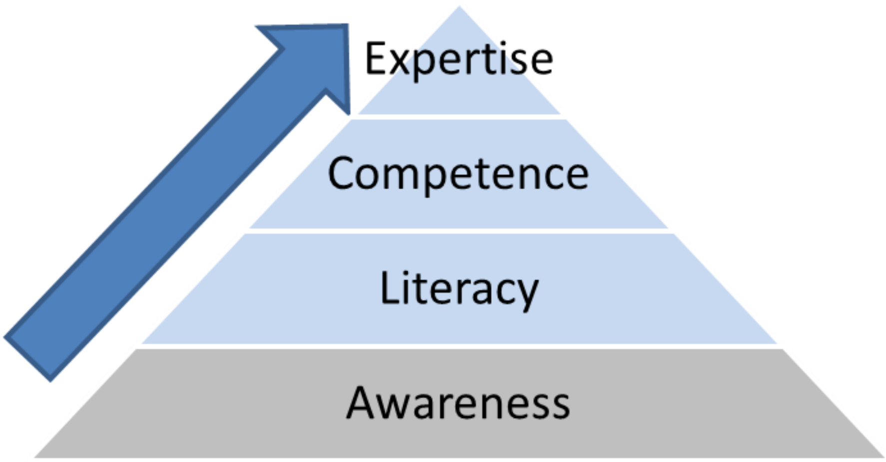

Figure 1: Digital Proficiency Levels (adapted from ECDL Foundation, 2011)

The complexity of the language and the overlapping concepts can make these terms difficult to navigate. In most of the literature the term digital literacy is considered in the broadest sense and it tends to relate to information and media literacy, internet literacy and ICT literacy. The concepts of information and media literacy are used in the context of using digital tools to find, process and organise information and interpret, use and create media respectively. Internet literacy relates to the ability to successfully interact with a networked environment [8].

However, considering this question of terminology, Li and Ranieri use the terms literacy and competence interchangeably and suggest that the terms are equivalent, favouring the term 'competence' in their research [3]. Generational impacts are also considered in the literature. Prensky clearly differentiated between digital natives and digital immigrants identifying those born after the mid-1980s as the first generation to grow up with digital technology [2]. While this is a useful concept, its identification of what Prensky considers a 'singularity' fails to take account of the multiplicity of advances large and small which have impacted on digital proficiency at a personal and global level.

While computer programming refers to the ability to write a series of instructions which ensure that a computer performs a specific task, coding is a term that technically refers to the development of those instructions in a machine-level language or instruction set. However, in more common parlance 'coding' is used interchangeably with 'programming' and 'computing' and tends to refer to the development of instructions at a higher level including object-oriented, and problem-oriented languages. While it is commonly accepted that the use of technology and the ability to interface with the World Wide Web and the networked world is important to 21st Century living skills, the ability to, as Prensky puts it, 'bend technology to one's needs' is clearly a higher level skill set that goes beyond the ability to use devices.

Steadman notes that the impetus to introduce coding or computing into the curriculum is straightforwardly economic and is based on the need to compete at a global level and on an aspiration that we can provide the context for the development of the 'next big thing' in technology [9]. While it is clear that not all technology consumers will need to be able to code, there is an expectation that learning to code will enhance their interactions with technology as well as contributing to other skills development [10].

2 SKILLS GAINED THROUGH CODING

The consideration of which skills are acquired and how they are acquired in learning to code is often related to the context within which the learning takes place. Scratch's inventor Mitchell Resnick is quoted as stating that Scratch teaches children to 'think creatively, reason systematically, and work collaboratively' [11]. Research on the earlier Logo language found that using the Logo programming language boosted the ability for abstract thought.

The concept of the social or collaborative learning environment fostered by the Scratch on-line community aligns well with a constructionist theory, focusing on the applied nature of the learning through programming in response to specific needs or the development of a meaningful product. This constructionist learning places importance on the development of individual cognitive skills in the context of engagement with others. Denner *et al*. explore the creation of computer games by middle school girls in the development of understanding of computer science concepts [12]. Salen claims that writing successful computer games involves 'systems-level thinking, iterative critical problem-solving, art and aesthetics, writing and storytelling, interactive design, game logic and rules and programming skills' [13, p. 307]. Firth claims that learning to code contributes to the ability for abstract thinking and problem solving [10]. Many authors refer to the ability to develop computational thinking through learning to programme and this is often linked to the development of transferable problem-solving abilities [14] [15] [16]. Exploring the rationale for the integration of computer programming into the school curriculum European Schoolnet identifies: [17]

- Logical thinking skills
- Coding and programming skills
- Problem-solving skills
- Employability in the ICT sector
- Attracting more students to study computer science in higher education
- Other key competencies

Computational thinking can encompass logic, precision, rigour and creativity and while it can be developed through programming activities it is considered to be both broader and deeper and with general transferability [18]. Research which has sought to identify complex algorithmic thinking development through computer game play in young children has identified algorithmic thinking, problem decomposition, pattern generalisation and abstraction and pattern recognition as types of computational thinking skills [19]. Ke's research illustrated that the use of Scratch-based computer game-making developed positive dispositions toward mathematics in middle-school children [20].

The European Commission elaborates on the kinds of skills that are necessary for active participation in the digital information society, often termed '21st Century Skills', including digital competence [8]. Researchers codify these skills sets in different ways but they may be generally considered to encompass three elements [21]:

- Personal and cognitive development: Critical thinking, problem-solving, creativity, collaboration, decision making

- Digital and media skills: Information literacy, Media literacy, ICT proficiency
- Active Citizenship: Flexibility and adaptability, personal accountability and goal-setting, productivity, leadership

There is general agreement that developing the ability to write code is likely to be of growing importance. Equally there is a recognition that a complex array of skills can be gained in developing these competencies.

Other researchers contribute to the understanding of the appropriate settings in which the acquisition of these skills can be supported. In extensive research on programming performance of elementary students, Feng and Chen conclude that non-specific goals and structuring scaffolds lead to superior comprehension of programming and that problem-solving performance is improved by non-specific goals and problematizing scaffolds. They further conclude that problematizing scaffolds are superior to structuring scaffolds in the development of self-regulation behaviour [22]. Lye and Koh also point to the importance of a constructionism-based problem-solving environment and the need for careful scaffolding and support for self-reflection [16]. So while it may be evident that skills can be obtained, the context and the support for the skills acquisition is also important.

If the skills which may be acquired through coding activities are to be recognised, the process will need to consider the four main stages identified by the European Union recommendation 2012 on the validation of informal and non-formal learning; Identification, Documentation, Assessment and Certification [23]. This collaborative research process sought to identify the skills that may be attained through the CoderDojo activities, building on the literature review and including practitioner perspectives.

3 SKILLS IDENTIFICATION AND EVIDENCING

In advance of developing a research structure to support the identification and, potentially, validation of skills gained by CoderDojo participants, a number of existing models that support the identification and documentation stages of validation were consulted at a European level. This consultation included consideration of the European Classification of Skills/Competences, Qualifications and Occupations (ESCO) framework which is a European Commission initiative [24]. The purpose of the initiative is the development of a common European terminology which will make it easier to identify the links between skills, competence, education and occupations throughout the regions. The second framework consulted was the e-Competence framework which was first established in 2008 with e-CF 1.0 and has since evolved to its current version e-CF 3.0 [25]. The purpose of the e-Competence framework is to establish common standards across descriptions of ICT skills requirements and gaps at a European level. The competence levels relate to levels 3 through to 8 of the European Qualifications Framework so there are aspects of the framework which are appropriate to the novice in ICT but also the expert.

In addition to these frameworks others such as Europass and Youthpass act as a repository for skills rather than being linked to particular role profiles. These initiatives support the documentation and evidence gathering in keeping with the concepts of lifelong and life wide learning.

4 RESEARCH METHODOLOGY

One of the aims of the CoderDojo Training in ICT Programming Skills project centres on the potential to link the digital competence which might be attained by participants with formal educational pathways thus potentially encouraging wider participation in third level education. This research piece reviewed the skills that might be attained, the means by which they might be referenced to a transferable reference framework and devised a customised framework to support initial indicators of skills acquired and the associated academic levels. The research was limited in that the partnership extended to four European countries and there were significant constraints on the level of funding and available timeframe. Early insights into CoderDojo activities highlighted the general age profile of participants and the number of hours of supervised engagement on a weekly basis.

In addressing the need of this project, whilst the existing frameworks informed and directed the research, a customised framework was developed to support the empirical research phase, mindful of the age profile and the identification of demonstrable skills by participants of the Coder Dojo movement. In considering all the existing frameworks which support the mobility of learning and learners and in gauging their relevance within an education development context, the European Qualification Framework (EQF) which links to national frameworks of qualifications was selected as a standards based approach which is transferable nationally and internationally. As the project partners are based within four different European countries this framework provides a transferable structure to translate the learning identified to national frameworks where appropriate.

The CoderDojo project skills analysis template was informed by the published standards of knowledge, skill and competence of the EQF levels one to three which aligns with the age profile of the individuals who actively engage with CoderDojo. It provided a useful observation tool, linking the appropriate EQF level with potential knowledge, skill and competence attainment and prompted the observer to indicate evidence of the learning attained where available. In this way the skills analysis template allowed learning gained to be evidenced in terms of task completion in the absence of a structured curriculum or learning outcome standards which may be outside the ethos of the CoderDojo movement and the focus of this research. The structure employed is an initial step in supporting the transfer to knowledge, skill and competence beyond CoderDojo.

The skills analysis relates the six classifications of knowledge and understanding, applying knowledge and understanding, communication skill, analytical skills, learning skills and autonomy and responsibility to evidence of CoderDojo task completion relative to the EQF level and informed by the age profile of the candidate. The framework was circulated to CoderDojo mentors and input from local participants was used to refine the observation questions. The analysis of the skills acquisition was conducted through observation by the CoderDojo mentors in each of the four participating countries recording the accomplishments of the chosen participants, the relevant level on the framework and including indications, where appropriate, of how the learning identified might be evidenced.

5 FINDINGS AND ANALYSIS

The skills analysis template, identifies demonstrable knowledge, skills and competences relevant to CoderDojo that align with the European Qualifications Framework Levels 1 to 3. This template was circulated to dojos in a number of different European countries – namely, Ireland, Spain, Poland and the United Kingdom. Mentors in the participating groups were requested to complete skills analysis templates for 10 randomly chosen participants. For each participant this involved recording the age profile and the identified knowledge, skills and competences demonstrated at each level of the framework by the participant together with an outline of indicative evidence where possible.

At the time of writing, just over 50% of the skills analysis templates had been returned. It was possible to elicit some interesting initial findings from the responses received.

Initial key findings can be summarised as follows:

- Almost 75% referred to participants aged 12 years and under
- Over 93% of participants were found to attain knowledge, skills and competences that align with EQF Level 1 irrespective of their age or country of origin. These participants were able to demonstrate their:
    - Knowledge and understanding of:
        - Key terms/concepts associated with computing - such as computer, a computer program, a programming language, operating system, and the internet.
        - File organisation on a variety of different storage platforms.
    - Application of knowledge and understanding through their ability to:
        - Organise their work into folders on a variety of different storage platforms.
        - Create, find, edit and save files in appropriate folders on a variety of different storage platforms.
        - Connect to a Wi-Fi network.
    - Communications skills through their ability to verbalise any issue they had with an assigned task to a mentor or peer.
    - Learning skills through their ability to:
        - Boot and login to a computer.
        - Find, edit and save existing work unaided.
        - Connect to a Wi-Fi network unaided.
    - Autonomy and responsibility through their ability to mentor their peers in completing some of the above basic tasks.
- All participants aged 13 years and over, and 74% of participants aged 7 to 12 years, attain knowledge, skills and competences that align with EQF Level 2. These participants were able to demonstrate their:

    - Knowledge and understanding of basic programming concepts such as program structure, variables, data types, sequence, selection and iteration and could demonstrate them in a visual/high level programming language.
    - Application of knowledge and understanding through their ability to develop a basic application by following a step-by-step worksheet.
    - Communications skills through their ability to verbalise any issues they had in terms of bugs present in their application to a mentor or peer.
    - Analytical skills through their ability to test and debug their application as necessary with assistance from a mentor or peer.
    - Learning skills through their ability to independently create their own application using concepts learned through previous structured learning.
    - Autonomy and responsibility through their ability to mentor peers to develop applications at a similar level.
- The attainment of knowledge, skills and competences that are aligned with EQF Level 3, are somewhat achievable by those participants aged 16 and over, and completely beyond the reach of younger children. In general, some of these participants were able to demonstrate their:
    - Knowledge and understanding through their ability to reuse knowledge acquired in one environment/programming language and adapt to a new environment/programming language.
    - Application of knowledge and understanding through their ability to learn a series of new/different skills by following a set of well-defined instructions and then applying these skills to a new, previously unseen, task.
    - Communications skills through their ability to communicate their learning and/or difficulties to their mentors/peers.
    - Analytical skills through their ability to identify a variety of approaches/solutions to a specific task and the select the best approach and justify the selection.
    - Learning skills through their ability to start learning a new programming language/environment without direct supervision.
    - Autonomy and responsibility through their ability to effectively mentor dojo members at a more junior level.

6 CONCLUSIONS AND RECOMMENDATIONS

In conclusion, the responses received to date illustrate that knowledge, skills and competences that align with:

- EQF Level 1 are demonstrated by all CoderDojo participants regardless of age or geographic location of the dojo.
- EQF Level 2 are demonstrated by all CoderDojo participants 13 and over and by almost 75% of participants aged 12 and under.
- EQF Level 3 are demonstrated by some but not all CoderDojo participants 16 and over and would appear to be almost totally unachievable by younger participants.

These findings, whilst preliminary, provide an indication of the skill level attainment of participants in the different age profiles. The findings align with the expectations of the research team in terms of levels of demonstrable skills attained. The skills analysis reports highlighted the variation in evidence and in availability of evidence of individual's learning. This may be due in part to the unstructured nature of CoderDojo activities in terms of scaffolding the learning opportunities and collation of records of individual learning. It also poses challenges in terms of defining appropriate evidence of learning at the levels of the EQF which is comparable across various age groupings of what is now a global movement.

Building on this initial research the potential to use evidence of learning gained through participation in CoderDojo activities in the process of transition from second to third level education within the four participating countries will be explored. While the findings to date are preliminary and based on a limited response it is likely that the recommendations of the completed research piece may point to the potential for the development of optional structures and frameworks to support the collation and evidencing of skills acquisition through participation in these voluntary coding activities. If that approach were to be adopted there would be resulting implications for the ethos of the movement and for the mentors and organisers

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