Challenging the Orthodoxies: A CoderDojo Perspective

Nigel McKelvey, Dr. Pamela Cowan
School of Sociology, Education and Social Work, Queen’s University, Belfast, Northern Ireland.

Abstract

The purpose of this study was to conduct research within the unorthodox context of a CoderDojo. Since 2011, the CoderDojo movement has been arguably plugging the gap in ICT education for children in Ireland. Ireland is viewed upon as a hub of activity for major computing companies yet coding or computer science is not taught in any meaningful way in schools. The Minister for Education, Richard Bruton in 2016 outlined a series of amendments to the curriculum at both primary and post-primary level to include coding and computer science. Therefore this study was timely in that it endeavoured to make educationalists aware of CoderDojos and that it would give a voice to the children participating in these voluntary activities. The data gathered provided insights into the factors that make CoderDojos appealing to young people but also shed light on the issues that might impede learning. With coding to become an integral part of the Irish educational system moving forward, it was important that this study took place so that educationalists and curriculum makers alike could understand how children at CoderDojos were learning how to code. The data gathered showed systems where social constructivism was evident. Children had freedom to move, to engage with peers (not necessarily their own age), to engage with More Knowledgeable Others (MKOs) such as professional computer programmers and to use their imagination by creating projects that were personal to them utilising an array of technologies. Using a combination of data derived from focus group interviews and overt observational data, this paper will present approaches and perspectives on computing education from children attending four CoderDojos in Ireland.

1. Profile and Background

Usually, a CoderDojo has young people between 7 and 17 years of age participating. This is not a strict rule as such with many other CoderDojos extending the lower limit of 7 to younger children. The CoderDojo Foundation does not stipulate any age, only that participants should have an ability to read basic words and understand how to spell commands. The mix of ages typically enhances the experience of Ninjas (learners) as younger children learn from more experienced and knowledgeable older children while the older children learn how to interact with and mentor their younger counterparts. The typical characteristics of a CoderDojo include an open, friendly and positive environment created where participants are not constrained to the usual rules of a typical classroom. There is therefore opportunity at a CoderDojo for both learners and mentors to challenge the orthodox approaches of learning.

2. Challenging the Orthodoxies

The term Computational Thinking was first used by [1]. Computational Thinking can be used to algorithmically solve complicated problems often associated with computer programming. The term appears in many computer science curricula throughout the world as it is traditionally associated with being a skill necessary for learners of computer programming. Currently Computational Thinking is generally defined as a set of cognitive skills and problem solving activities that include (but are not necessarily limited to) the following characteristics [3][4]:

• Using abstractions and pattern recognition to represent the problem in new and different ways
• Logically organising and analysing data
• Breaking the problem down into smaller parts
• Approaching the problem using programmatic thinking techniques such as iteration, symbolic representation, and logical operations
• Reformulating the problem into a series of ordered steps (algorithmic thinking)
• Identifying, analysing, and implementing possible solutions with the goal of achieving the most efficient and effective combination of steps and resources
• Generalising this problem-solving process to a wide variety of problems
Teachers in STEM-related disciplines that include computational thinking, endeavour to allow students to practice problem-solving skills such as trial and error [5]. The concept of Computational Thinking has been criticised as being too vague, as it is often not distinguished from other forms of thought [6]. Additionally, many computer scientists are concerned about the promotion of Computational Thinking as a substitute for a broader computer science education, as computational thinking represents just one aspect of the field [7].

According to [8] and [9], a core source of engagement in education is knowledge itself which has become ever more fluid. [10] have stated, "what we have here is a transition from a stable, settled world of knowledge produced by authority/authors, to a world of instability, flux, of knowledge produced by the individual" (p. 207). The notion of organised knowledge clearly defined by experts is, in some instances, being sidestepped to give way to continual flux. Many researchers [11] [12] consider this view of knowledge as controversial and also consider it to be challenged by individuals finding the move from expert to amateur knowledge producers unsettling. [13] outlines that the view of experts as sole providers and evaluators of information is one which cannot be sustained in this world of ever advancing technology. Society are persistently exposed to a continual flow of data which enables people to build new concepts and gain new knowledge in new ways.

Research highlights that many are placing importance on the need for differential approaches to both content delivery and learning so that optimum intellectual development can be fostered [14] [15] [16] [17]. Striking a balance between critical thinking and creativity is presented as being essential in the construction of knowledge where a single solution to a problem is not the answer [18].

[19] outlines, that within a constructivist learning environment (such as a CoderDojo), there is a need for:

- Knowledge construction, not reproduction
- Working with real world knowledge
- Realistic and relevant real world environments
- Emphasis on many representations and interpretations that recognise varying perspectives
- Collaboration and social negotiations
- Metacognition and reflection on learning
- Self-regulated learning
- Negotiated goals
- Evaluation as self-analysis

Fluidity as outlined by [20] is one that can help with theorizing the topology of a CoderDojo. Conventional learning spaces tend to involve teacher led instructions, rigid learning outcomes, memorising facts, standardised tests, an isolated classroom dissected from the real world and a focus on individual achievement [21]. The new and unorthodox learning environment offered by CoderDojos are learner centred with hands-on practical experience, problem based and project oriented. The traditional teacher role is also replaced by one where a mentor or computer programming professional leads and guides without a steadfast structure and without facilitating a classroom hierarchy. There is a fluidity present where interconnections and interrelations between learners and any other actor involved are fostered and encouraged when learning occurs [20]. The CoderDojo environment appears to cross the traditional student/teacher boundaries as well as the usual boundaries that exist between an individual and a collective. [21] suggest that fluidity in a learning context can create transformations with discontinuities. Fluidity in this sense helps to articulate new educational environments as active and interactive collectives where collectives are not uniform entities but are rather emerging from the constructive interference of individuals and various collectives.

[22] presented the significance of an adult’s role and indeed the role of capable peers. The research identified that one of the key challenges for adults was defining the limits of the zone. Decisions as to whether the support or scaffolding could take the learning beyond the child’s current capabilities. Bronfenbrenner agrees, and placed a great emphasis on the relationship between adult and child; “Learning and development are facilitated by the participation of the developing person in progressively more complex patterns of reciprocal activity with someone with whom that person has developed a strong and enduring emotional attachment and when the balance of power gradually shifts in favour of the developing person” [23] (p. 60). When considering a learning system, this suggests that the ZPD is enhanced where there is a strong relationship between the subject (child) and the community (MKO). Where the MKOs can relay their approach to resolving a problem in such a way that provides a limited amount of guidance and affords the learner an opportunity to watch and practice skills, then it is possible that the child can remain active within the learning system.

In a traditional educational context, it is arguable that the zone could become contained or even constrained by curriculum (rules) and the pressures facing educationalists to meet assessment goals (division of labour). A less formal context, where the adult is not a trained educationalist striving to meet a set of criteria, has the potential to guide the children further. Therefore the classification of context is important when striving to take children beyond what might be perceived as their academic limit.

The pedagogic principles of the Revised Curriculum which characterise the vision proposed
by the Primary School Curriculum in the Republic of Ireland [24] have the potential to facilitate less formal approaches and utilise skillsets of other nongovernmental organisations working in professional contexts:

- the child's sense of wonder and natural curiosity is a primary motivating factor in learning.
- the child is an active agent in his or her learning.
- learning is developmental in nature.
- the child's existing knowledge and experience form the base for learning.
- learning should involve guided activity and discovery methods.
- language is central in the learning process.
- the child should perceive the aesthetic dimension in learning.
- social and emotional dimensions are important factors in learning.
- learning is most effective when integrated.
- skills that facilitate the transfer of learning should be fostered.
- higher-order thinking and problem solving skills should be fostered.
- collaborative learning should feature in the learning process.
- the range of individual difference should be taken into account in the learning process.

While these characteristics pre date CoderDojos, the need and desire to expose children to a new curriculum which embraced critical thinking, problem solving and giving the child agency in their own learning environment, was important. When the INTO’s report was written, CoderDojos did not exist but the movement does appear to align with the aspirations presented in the document. The characteristics combined suggest a learning context with a philosophy that affords learners opportunity to be social and inquisitive. The potential constraints of curriculum assessment on the ZPD [25] could be alleviated via a less formal approach to learning where stress about examinations is not a factor.

A definition of non-formal education as offered by the International Standard Classification of Education (ISCED) [26], outlines that "the defining characteristic of non-formal education is that it is an addition, alternative and/or complement to formal education within the process of the lifelong learning of individuals" (p. 11). [27] noted that in the 1990s, attention given to non-formal education was reluctant and hesitant. As the post-Jomtien (World Conference on Education for All (EFA) in Jomtien (1990)) era focused heavily on formal education, governments and agencies have, as a result, exhibited little interest in non-formal education [28]. The exception, however, to this stance is that of agencies concerned about the social conditions of marginalised children and young people such as the United Nations Children’s Fund (UNICEF) and Save the Children (SCF). In the current post-Dakar (World Education Forum in Dakar (2000)) decade, opinions are evolving again. There are indications that non-formal education, at various levels and for various groups, is gaining in popularity. In recent times, several development agencies, such as the Swedish International Development Cooperation Agency (SIDA) and the World Bank, have reassessed their position on adult education in particular [29][30][31][27]. In addition to UNICEF and SCF, other agencies have given their support for the provision of non-formal education to children and young people, such as the United States Agency for International Development (USAID), the Netherlands, Ireland and Switzerland [28].

Controlling one’s own learning aligns with the CoderDojo philosophy. [32] (p. 45) posits that, “Piaget, Freire, Havighurst, Coleman, Brookover and literally hundreds of other psychologists, educators, sociologists and philosophers have indicated clearly where education should be and where, instead it wallows in inefficiency, crust rigidity and stubbornness. Most of those critics advocate changes of the existing educational system and there is ample evidence of the need for dramatic efforts in this area.” Agency in learning via a less formal approach may be the catalyst required. For agency to be achieved, the approach to content delivery must evolve.

### Table 1 Formal, Informal and Unformal Learning [33]

<table>
<thead>
<tr>
<th>Formal</th>
<th>Informal</th>
<th>Uniformal (non-formal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visits to museums or zoos</td>
<td>Visits to museums or zoos</td>
<td>Subject matter experts present at quizzes without wheeling students</td>
</tr>
<tr>
<td>other flora and fauna</td>
<td>Visits to museums or zoos or other flora and fauna</td>
<td>Agency - students divide themselves into groups to solve a problem</td>
</tr>
<tr>
<td>exhibit with a report required by university afterwards</td>
<td>Listening to radio, watching TV, programmes on educational or scientific themes</td>
<td>Understanding final learning not following a curriculum</td>
</tr>
<tr>
<td></td>
<td>Reading texts on science, education, technology, etc.</td>
<td>Using assessment</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Participating in scientific research</td>
<td>No assessment</td>
</tr>
<tr>
<td></td>
<td>Attending lectures and conferences</td>
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<td></td>
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</table>

[33] outlines that the success of an unformal learning environment is dependent upon the level of motivation amongst the students and the quality of materials utilised so as to uphold the motivation levels ensuring that the expectations of the individuals are met. Finally, the provision of nonformal institutions with support of a multidisciplinary team is important in enabling the environment to continue with longevity. The nature of the environment is one which also aids a learner in gaining skills for life.

[34] presents 'Meddler-in-the-Middle' as an "active interventionist pedagogy in which teachers are mutually involved with students in assembling and/or disassembling knowledge and cultural products. Meddling is a re-positioning of teacher and student as co-directors and co-editors of their social
world" (p. 288). In a CoderDojo context, 'meddlers' (mentors) may have influence due to their perceived position by the children and their professional backgrounds (as programmers or student programmers or class teachers). The energy that 'meddlers' bring to the environment does not suggest 'command and control' but rather "support and direction through structure-rich activity in which they themselves are highly involved” [34] (p. 290). This therefore suggests both the potential for a positive as well as a negative ‘meddler’ in an unformal context.

The unformal learning environment offered by a CoderDojo aligns itself with the theory of ‘learning as inquiry’ as outlined by [35]. Learning as inquiry places the question at the foreground rather than the answer and positions learning with the learner as opposed to material as part of a curriculum. It is prudent to note that answers are important, however, learning as inquiry also values the processes associated with inquiry and their impact on knowledge, skills and dispositions toward learning [35]. These impacts could have the potential to positively affect how a learner approaches learning in all walks of life.

As suggested by [36] (p. 5), "the MKO can also be viewed as a learning object or social software which embodies and mediates learning at higher levels of knowledge about the topic being learned than the learner presently possesses". Arguably, the unformal learning space facilitates a transferral of some - or most - of the responsibility of a child's learning path from the mentor (back) to the learner. As a result, it also implies that the child is regaining the control of their own learning path and its design (therefore remaining within the inner triangle of AT; the ZPD). This personal learning space facilitated at a CoderDojo may be more than a "tool to provide access to 'More Knowledgeable Others' but as part of a system to allow learners to link learning to performance in practice, though work processes. And taking a wider view of artefacts as including information or knowledge accessed, reflection on action or performance may in turn generate new artefacts for others to use within a ZPD” [36] (p. 5).

Thus, it is possible to consider the relationship that exists between the ZPD and unformal learning spaces as an opportunity to construct and seek out the tools and people that will assist a learner through the ZPD [37]. The unformal setting afford opportunities for children to engage with lifelong skills that could help enhance knowledge and skills in multiple ways.

Lifelong learners have many characteristics however some of the more salient attributes include individuals who have an insatiable appetite for knowledge, are social learners, do not merely memorise information and act as educators or teachers themselves [38]. These traits materialise as someone who continually seeks to improve their knowledge and skills by actively seeking out new learning experiences. In a CoderDojo, this may take the form of searching online resources or seeking out expert knowledge from others. Lifelong learners are facilitated in a CoderDojo context due to its social aspect where groups can come together and engage in discussions around their subject or project of interest. CoderDojos are keen to ensure that Ninjas can create a project in an applied way that allows the user to practice skills and create something tangible. The research and development aspect of a Dojo allows a child to go beyond simply absorbing information and enables them to synthesise and apply what has been learned. The unorthodox nature of Dojo delivery ensures that there is no ‘teacher’ and people can openly share what they know. Children are often encouraged to help each other and relay their findings, thus facilitating them in acting as a MKO.

The field of education is ever changing and the onslaught of technology in the past decade or more has forced a change in attitude among many educational stakeholders. With technology now being used in many aspects of education, it is important to consider if utilising technology has an impact on the dispositions of learners. For knowledge to be truly constructed, an environment should endeavour to invite and stretch the habits of its learners. However, [39] posits that "hard thinking focuses the brain’s attentional field on that which is probable, plausible or ‘sayable’, and thus makes it miss more intricate or unexpected details and patterns in experience” (p. 5). Therefore, it might be considered prudent to foster positive traits and dispositions organically rather than via prescriptive methods.

### 3. Methodology and Analysis

This study explored the experiences of children (aged 10-13) participating in CoderDojos in one county of Ireland. The research incorporated qualitative (observations and focus groups) and quantitative (survey) methods. Four CoderDojo Locations (A, B, C and D) were identified. These four locations had an existing Dojo (running for more than 12 weeks). They were selected due to their profile diversity and geographic location. The children here were observed, completed a survey and participated in focus group interviews. In this paper, pseudonyms have been used to protect the participant’s identities.
The observational data collected offered an insight into the complex relationships that exist between various elements at a CoderDojo. It demonstrated the importance of where a child might be placed within each learning system if the ZPD is to be maintained or extended. It also served to highlight the factors that may influence agency in learning and thus impacting the ability to learn and grow in a meaningful way. Subtle changes to a mentor’s approach, the layout of a room, the tools made available and the rules applied can have a profound effect on the potential outcome.

The observations also revealed that even in the face of adversity (poor room layout, limited tools, rules, a false sense of the discipline and sometimes a high demand placed on cognitive abilities) the children appeared to have fun and enjoyed being there.

The opportunity to engage in limitless problem solving where the learner exhibits determination (tenacity) and recognises that there are more than one way to achieve a result is evidenced by John (B2) when he said:

John: Well coding, ya see, there’s loads of ways of doing it. If ya wanted to write a word you could write a small code or a big code, and you could do it in many ways, only with school subjects, there’s just limits whatever way whatever direction ya go.

John’s response also suggests that his options to learn are limited in a traditional school environment. The notion of a school applying “limits” and being restrictive is a cause for concern for educationalists. Offering learners opportunities to engage with a task in multiple ways is certainly a trait of CoderDojo that could be implemented in a school setting. This of course assumes that there is time and scope within the curriculum to facilitate this.

John’s comments are supported by children at CoderDojo A where they also suggested that there was less opportunity for agency in learning at traditional school.

Sue mentioned being introduced to new people at a CoderDojo. The social aspect of a Dojo is important where children of different ages are learning together in a social context. There is good opportunity for the children to learn how to interact with others in a more productive manner and to learn empathy for others who might be encountering difficulty. These options are often not available in a school setting where, traditionally, a class is comprised of children of a similar age. It is therefore arguable that a CoderDojo is providing its Ninjas with agency in their approach to learning; a potential lifelong skill which supports [22] where an importance is placed on the role of others and capable peers in helping children working in their ZPD.

The fact that children attending CoderDojo B are doing so on a Saturday morning off their own volition demonstrates a certain level of commitment and desire to be there. The freedom to go or not is itself a characteristic of agency as presented by [40].

Emma’s dialogue refers to having an opportunity to practice. This is perhaps further evidence of a learner who is engaged (intent participation) with the material and who is demonstrating tenacity and grit in her approach. It is therefore arguable that tenacity and determination are possible by-products of a learning environment that fosters agency.

Lucy in CoderDojo C also expressed her satisfaction with having choice but used the words “subject” in reference to the CoderDojo and also alluded to situations where they have “instructions”.

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Table 2 CoderDojo Profiles

<table>
<thead>
<tr>
<th>CoderDojo</th>
<th>Environment</th>
<th>Age Group</th>
<th>Mentor Profile</th>
<th>Technologies Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Secondary school computer lab using PCs.</td>
<td>10-13 years</td>
<td>Six computer science degree student volunteers</td>
<td>Scratch, HTML, Miasma</td>
</tr>
<tr>
<td>B</td>
<td>Family Resource Centre using PCs. Saturdays.</td>
<td>5-14 years</td>
<td>Computer Programmers.</td>
<td>Scratch, HTML, Java/Swing, Python</td>
</tr>
<tr>
<td>C</td>
<td>Primary School classroom using laptops during school time. Fridays.</td>
<td>10-11 years</td>
<td>Uses class teacher with the addition of two computer science degree students volunteering</td>
<td>Scratch</td>
</tr>
<tr>
<td>D</td>
<td>Secondary school computer lab using PCs.</td>
<td>9-14 years</td>
<td>Computer Programmers.</td>
<td>Scratch, HTML, CSS, Javascript, Python, Mindstorms, 3D Printing</td>
</tr>
</tbody>
</table>

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CoderDojo C is delivered by the usual class teacher during school hours, therefore Lucy’s point is perhaps a reference to the teacher using a more traditional teaching approach to delivery on occasions (teacher centred). Interestingly, Lucy’s comment doesn’t infer a deeper understanding that agency in learning is beneficial, in that it would help her to gain a better understanding of the problem, but rather that it is less constrained than traditional “subjects”.

The focus group interviews revealed what fun meant to the children and how it influenced and affected their approach.

CoderDojo B (2)

Researcher: Tell me what you think of a CoderDojo?
Billy: Oh, well I think it’s very fun and like your imagination... there’s no limit to it. Like you can, whatever you can think of you can do it.

Billy at CoderDojo (B2) appeared to cite a Dojo as a context that provided him with a world of possibilities. He referred to the fun aspect of using his imagination and that in turn, anything was possible. The confidence building associated with ‘fun’ could arguably act as an intervention to a barrier of the ZPD where children might otherwise experience boredom or encounter resource issues.

CoderDojo D

Emma: Well I would say it’s a class not only to help you learn how to use computers more constructively, more intensively. It’s also a class to find like-minded people.
Researcher: Oh Yeah, Oh. Anything else?
[Short pause]
Nathan: Oh, Yeah. It’s not really all about programming, it’s about seeing what you can design, what you can come up with and it makes you think in different ways as well.

The participants at CoderDojo D appear to have been afforded opportunities to understand how to become a MKO (More Knowledgeable Other). Emma seems to understand that there’s more to a Dojo than simply using a computer, she appreciates creativity and the opportunity to interact socially with peers who share a common interest. These ‘softer skills’ are equally as important in allowing her to break down any ZPD barriers and enable her to disregard any false sense of the discipline.

Nathan’s response was quite similar to Emma’s where he also appeared to understand the many different roles that exist within the discipline. The ‘fun’ aspect of the Dojo appears to nurture creativity and encourage it. Nathan’s comment about “thinking in different ways” is maybe evidence that CoderDojo D has managed to dispel another barrier to ZPD: egocentric subjectivism [41]. Nathan appears to understand that there are many solutions and much to be gained by thinking in different ways.

The opinions of the children involved in a CoderDojo about their learning environment are of great interest. Also of interest is the potential cognitive impact of such an environment on learning. CoderDojo A was in a school environment, after hours and delivered by computing students. The children were asked if they liked the room in which their Dojo took place.

CoderDojo A

Pete: I think CoderDojo should take place in a quiet room that has a lot of technical stuff and computers in it.
Paul: I think CoderDojo could kind of be in a big but small room, sort of kind of a medium one, which the tech that Pete was on about.
Researcher: And is the room that your CoderDojo takes place, is that OK?
Mike: Good
Paul: It’s Ok.
Mike: Cos it’s small and compact!
Researcher: It’s compact? OK.
Mike: Because it has computers and because you like go into groups and have teamwork together instead of like struggling with it by yourself.

A CoderDojo usually conjures images of fun and noisy interaction. The dialog above would suggest that the children here prefer a slightly more subdued environment. They liked the social aspect to their Dojo and enjoyed the option of being able to collaborate but they also used words such as “compact”, “small” and “quiet”. These adjectives suggest learners who wish to focus and be studious. The have chosen to go to this Dojo voluntarily and appear to genuinely want to learn. The boys also suggested that the room should have “tech”. The idea that the children wanted to see technology in the room is an indication of a desire for more inspiration. The children are aware that a CoderDojo is dissimilar to their usual learning environments and as a result, they want their CoderDojo context to reflect that disparity. The inclusion of technology in the room is an obvious request.

4. Conclusions

[42] as well as [43] suggest that gaming as a learning tool has the potential to provide learners with contextualised problem solving spaces and helped bridge the in/out-of-school learning gap. There is also scope for social interactions to be improved through gaming where the rules of play are communicated and respected by all participating. Additional evidence was provided by [44] where positive correlations were found between gaming as
a team and learning versus gaming alone. A CoderDojo is an opportunity for children to learn from and with peers. The data presented in this paper is merely a snapshot of the research conducted, however, it revealed many elements (agency, technology, environment, mentor influence, fun, aspirations, problem-solving, projects and challenges) as being important when creating an unorthodox learning space for children to engage with material such as coding related activities. The data may prove useful to educators hoping to adopt and implement the newly proposed curriculum for Computer Science at Leaving Certificate level in the near future.

5. References


