A Curriculum Framework and Assessment Approach for Computational Thinking in the Early Years

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Abstract

In light of current developments, there is an increasing effort to integrate computing-oriented activities into the education of children as young as two years old. Although the computing strand is not officially addressed in the Early Years Foundation Stage Statutory Framework (DfES, 2024), a small number of early years teachers in England implement computing-oriented activities to ensure that young children progress from early years to Key Stage 1. A particular gap in the field is that previous research on computational thinking concepts never or rarely establish curriculum links in a way that teachers can utilise in their practices. This theoretical article therefore proposes a curriculum-based framework for both teaching and assessing computational thinking (CT) in early years education as assessment is not possible without pedagogic guidelines. Offering a sample lesson plan with links to the Early Learning Goals, this framework aims to encourage teachers, including those without specific computing training, to integrate CT concepts more explicitly into their teaching and enables them to monitor and assess their pupils' progress in relevant skills.

Key words: computational thinking, early years, identifying CT, curriculum framework, assessing CT skills.

1. Introduction

Many researchers of computational thinking (CT) propose that basics of computational science or digital technology could be taught in preschool establishments, and have published studies in which very young children successfully learn to program and code utilising computer games or robots (Bers et al., 2019; Fessakis, 2013; Papadakis, 2020) or other coding devices such as Code-a-pillar (Wang, 2021). It is suggested that preschool children would benefit from learning CT skills alongside reading and writing (Lee, 2022; OECD, 2023; Wing, 2006), however it has been noted that often teachers do not have the time or training to teach these skills (Wang, 2021; Wang et al, 2023) and are reluctant to add to an overloaded curriculum (Dong, 2018; Ireland, 2015). While CT studies may take place within preschool establishments, they rarely advise on how the subject can be integrated into lessons (Yücelyiğit, 2023), that the specialist equipment may be expensive for early years' establishments (Dong, 2018), and that teachers will usually only teach to national curriculum guidelines (Barr & Stephenson, 2015), but there are many suggestions that the National Curriculum needs to change, and younger children need to start to learn some form of CT (Dong, 2018: Lee et al, 2022).

This innovative article examines the possibility and practicality of teaching and assessing CT skills to children in the early years or preschool. While many research articles support the concept of changing the curriculum there are no, or very few concrete suggestions that teachers may follow. We examined whether the Early Years curricular framework could be adapted by early years teachers in order that children could be assessed on the development of elementary CT skills before entering into the more formal education required by the Key Stage 1 curriculum guidelines and provide suggestions for CT activities that can be incorporated into the existing curriculum.

Literature review

Computational thinking as a concept for teaching has come into prominence in the last few years. While it is often used interchangeably with computer programming in the literature (Shute et al., 2017), some theorists suggest this is a misconception and that CT should be thought of as an ongoing thinking process rather than having a code-like outcome (Lee et al., 2022; Wing, 2006). Researchers have discussed what CT could consist of, and relevant assessments developed for, primary-aged children by mapping the teaching and assessment to a specific curriculum (Snow et al., 2019; Waterman et al., 2020), however, there is a paucity of information on CT for children in the early years in common with many other countries such as Sweden (Otterborn et al., 2019) and Brazil (Gomes et al., 2018).

Consideration must be given to why it is important to teach CT to very young children particularly as the subject is not addressed in many countries' national curriculum (Çimşir et al., 2024; Dong, 2018). Results from research studies suggest that it is possible to start teaching aspects of CT from the ages of 3 years (Bers et al., 2019) using robotic toys such as the KIBO, while Critten et al (2021) started teaching unplugged coding using guided play to children aged from 2 years. The results in both these and other studies showed that the activities and guided play '… promoted communication, collaboration and creativity…' (Bers et al., 2019, page 1). Many studies utilised robot-type toys in their studies while a number of researchers suggested using play activities to promote CT were related to lower costs and could provide a better foundation for plugged computer lessons in later education (Saxena et al., 2020). Whichever approaches are used to teach CT in the early years, Bers et al., (2019) stressed that more research needs to focus on how learners engage with CT and learn from their lessons, and how teachers can introduce these new educational areas into their curriculum.

Thus, many researchers into CT regard the introduction of aspects of CT in the early years to be desirable as it could enhance the development of the children's creativity and communication abilities (Bers, 2019), however many teachers regard the use of computers and digital media to be a threat to children's social abilities and the development of their play (Dong, 2018). Further, a lack of training opportunities and practical classroom guidance have resulted in many teachers unsure and resistant to teaching CT in their lessons (Wang et al., 2021; Wang et al., 2023), while Bers et al., (2019) consider that appropriate pedagogical approaches must be developed. In order to ensure this many teachers need to have the time and opportunity to undergo training in CT and how it can be incorporated into lessons (Çimşir et al., 2024). Teachers in China were interviewed to find out their views on the teaching of CT before they took part in the training of pedagogical approaches to CT in their schools. The teachers felt that designing lessons involving ICT took a lot of preparation time and effort, but after their training had taken place, they felt that 'awareness-raising' was the most important aspect of the training, and many of the participants appreciated the way that CT could be incorporated into other subjects such as drama lessons (Dong, 2018). These arguments raise the question of why aren't opportunities given to promote CT in the early years and why aren't teachers given the benefit of training in a subject which is considered by researchers to be so important.

Theoretical framework for teaching CT in the early years

Government guidelines for Key Stage 1 children, aged from 5-7 years in England, propose that children should have knowledge of computer programming: '(to) *understand: what algorithms are, how they are implemented as programs on digital devices, and that programs execute by following precise and unambiguous instructions*.' (DfE, 2013, p.2). There is a case to be made that foundations could be laid in the early years period which would enable children to gain concepts of CT before they reach Key Stage 1. Wing (2006) suggests *'To reading, writing, and arithmetic, we should add computational thinking to every child's analytical ability'* (pp 33) as they will need CT mental tools for their development in computer science. This case is made stronger by the fact that many young children aged between 0-5 years are already using digital apps on phones and tablets (Bers et al, 2014; OECD, 2023; Ofcom, 2023). It has been suggested that preschool children benefit from learning to program as it may encourage the development of computational thinking skills such as communication and collaboration; logical thinking and reasoning; and the organisation and evaluation of ideas (Fessakis et al., 2013; Gomes et al., 2018). This theoretical article examines how CT skills could be incorporated into the existing Early Years Curriculum Framework (DfES, 2024) and consists of four main areas for consideration:

- Concepts of teaching CT in the early years, in particular the CT skills that can be developed for preschool children;
- Incorporating computational thinking in the early years' curriculum and how these skills can be taught utilising the existing framework;
- Developing children's thinking abilities by providing appropriate lessons and resources;
- Examples of assessment which can be included in the existing assessment programmes.

2. Concepts of teaching CT in the early years

In order to examine whether it is appropriate to teach CT skills in the early years, it is necessary to consider what aspects of CT can be taught to children who may not yet have developed reading or writing skills and may not be able to use a computer. Figure 1 shows a breakdown of the main CT themes identified in the literature (see Bers et al, 2014; Fessakis et al, 2013; Lee et al, 2022; Wing, 2006).

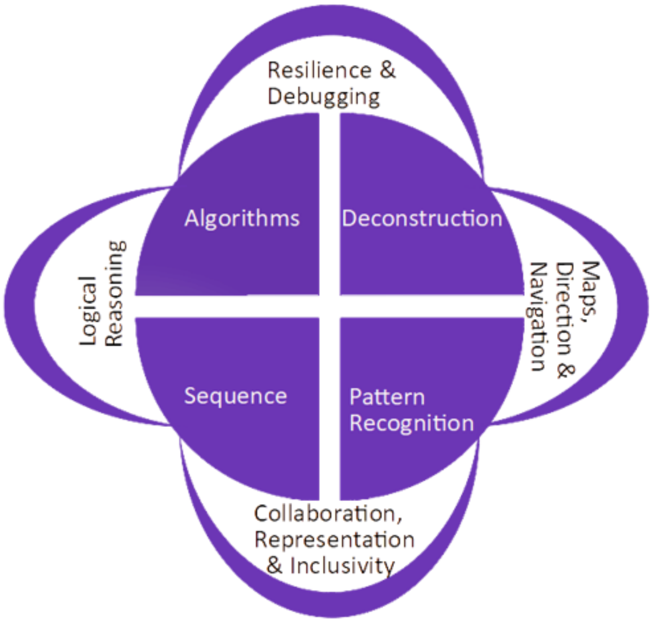

Figure 1 A representation of the key components of computational thinking (Hagon, 2024)

Looking at a representation of CT skills (Hagon, 2024) in Figure 1 and Table 1, certain aspects of CT can be incorporated in play activities/ and or lessons for children in the early years such as:

- Listening, communication and collaboration – how to work together, teaching children that with team work things can be easier (Bers et al., 2019), and links with communication (Papert & Harel, 1991). Pairs and group working, listening and communicating to promote inclusivity, being able to celebrate everyone for their unique skills. Many young children may be more familiar with apps and digital devices, and co-constructing and collaborating with teachers may take place in lessons and activities (Dong, 2018)

- Logical thinking, analysing and problem-solving (Caeli & Yadav, 2020) – the idea of questioning a process first or establishing logical reasoning to communicate with an adult to explain why a sequence was debugged or explain the rationale behind a particular activity or action (Bers, 2018). This can be done prior to an activity or after depending on whether the child has had previous experience, aided by teachers scaffolding the learning, assessing progress, and then giving opportunities to repeat the activity or a similar activity to measure progress

- Algorithms, sequencing, debugging, resilience – following rules will help when the child has to both give and receive instructions and directions; investigating where the problems are with an algorithm, sequence or pattern and backtracking to fix them; learning the art of behaving appropriately when something unexpected happens, trying again, thinking of an alternative, asking for help; fostering a growth mindset and developing confidence in their abilities (Smiley & Dweek, 1994). Pattern recognition, sequencing and debugging as these enable children to learn about creating loops in code

- Maps/Navigation and Direction – when learning about software programs such as ScratchJR and BeeBots in later academic years, the knowledge of left and right, backwards and forwards is critical so utilising map skills with landmarks and navigation supports the scaffolding for this learning ((Kalogiannakis & Papadakis, 2020; Papadakis, 2021). This affords the teachers lots of opportunities to look at the local environment in the classroom, playground and local play areas which is already in many curricula.

Whilst the following are not primarily considered to be CT themes, they support multiple positive skills and attitudes that complement and enhance the EYFS PSHE content:

- Inclusivity – the act of being inclusive, celebrating everyone for their unique skills, advocate for oneself and each other based on observing skills and abilities
- Representation – fostering the confidence in children to stand up for them/their selves and their peers.

Adding these themes to the curriculum present a huge challenge to teachers when the curriculum is already overloaded (Dong, 2018; Wang et al, 2021). This next section looks at how many of these themes can be incorporated within existing school projects.

3. Incorporating computational thinking in the early years' curriculum

This section describes how CT can be incorporated into the curriculum given that many teachers are not trained in teaching any form of digital technology. While researchers advise the incorporation of digital technologies into the early years curriculum, the guidance is very much at the level of policy directives rather than direct guidance for teachers' lessons, (e.g. OECD, 2023). Many experienced teachers are now being asked to teach CT skills without having been trained in computer science or computing education (Sentance & Csizmadia, 2015). Research suggests that teachers in the early years commonly lack proficiency and confidence in programming-related knowledge and skills, and they seek clearer curriculum guidelines to accompany their teaching efforts (Otterborn et al., 2019; Otterborn et al., 2020). We have married up existing targets in the framework with concepts of CT from Figure 1 that are linked by researchers (e.g. Lee et al, 2022). Table 1 displays the three main areas in the framework: communication and language; physical development, and PSHE.

Table 1: Linking CT skills with the Early Learning Goals

Early Learning Goals (ELGs)	**Specific Targets**	**Links with CT skills (taken from Figure 1)**
Communication and Language	Interactions with others	Listening, communicating and collaborating
	Commenting	
	Answering questions	
Listening, attention and understanding	Language and vocabulary development	
	Self-commenting	Logical thinking, analysing and problem-solving
	Asking questions	
Physical development	Singing and dancing	

Gross motor skills Fine motor skills	‘Robot’ dancing Directionality/ orienteering Sequences of movement	Algorithms, sequencing, debugging, resilience Learning directional language (forwards, backwards, left, right and pause)
	Making patterns Guided play activities	Identifying, sequencing, debugging

Physical, Social and Health Education (PSHE)	Friendships Collaboration Interpersonal skills	Pairs and group working, listening and communicating
Self-regulation Managing self Building relationships	Modelling	Collaborating, listening, logical thinking, problem solving

Previous research has identified teachers' reluctance to integrate computing and CT into their teaching practice when there are no clear curriculum or government guidelines (Dong, 2018; Israel et al., 2015). Linking the above skills to CT themes will assist practitioners in introducing elements of CT into the setting and these will provide an introduction or baseline for the National Curriculum requirements for CT in Key Stage 1 (DfES, 2024). A further advantage is that practitioners can use the current Early Years assessment framework which addresses the areas of learning as well as covering CT skills, further utilising cross curricular learning opportunities.

It is recognised that ‘*children’s development, learning and wellbeing are best served through play*’ (Smedley & Hoskins, 2020, p.1202), thus, by integrating CT themes into structured, play based activities, children can learn the concepts in an accessible way and teachers can teach these concepts without having to learn over-engineered techniques or overwhelming skills that are simply irrelevant to young children (Lee et al., 2022). CT skills can dovetail into a typical school's curriculum planning and by thinking laterally, many lesson targets can be cross curricular with a slight change of focus and a little more direction by the teacher to allow for the sessions to have a CT focus. For example, lessons incorporating patterns are looked at in the maths curriculum by exploring and identifying similarities and differences in shapes, colours and sizes in the surrounding world of young children (Gifford, 2005). Additionally, basic concepts of algorithms can be addressed in communication and language with a self-regulation early learning goal stating that children should follow a set of instructions (DfES, 2024).

4. Developing children's thinking skills

There has been discussion by researchers as to how CT could be incorporated into teaching and learning within early years establishments (Lee et al., 2022), and if it is appropriate to try to develop these skills at such a young age. Earlier studies have suggested that very young children are not able to think abstractly and so are limited in learning programming and coding by their developmental levels (Clements and Guilo, 1984). These constraints are also suggested by Piaget's theory as he reports that preschool children have difficulty in using logic and reasoning; being able to mentally manipulate information, and taking other's perspectives (Piaget & Inhelder, 1973). However, a shift in perspective has emerged due to additional research, which demonstrated that preoperational children were less egocentric and animistic than Piaget had initially suggested (Newcombe & Huttenlocher, 1992). His theory, as a result, received criticism for potentially underestimating children's cognitive development (Siegler, 2016). Starting from a very young age, children are now recognised as individuals with elevated cognitive capabilities and an inherent tendency for exploration (Gopnik, 2010). It can be difficult for a teacher untrained in computer science to change their pedagogical focus, but researchers suggest that with the right teaching approaches, equipment and support from adults, preschool children are able to develop CT skills and coding skills (Bers et al., 2014; Bers et al., 2019; Gomes et al., 2018).

Many research studies start with encouraging the children to learn algorithmic thinking with the use of games and songs such as 'Simon says' and various nursery rhymes the Hokey Cokey (Hokey Pokey) and the use of particular books which have a clear sequence or pattern of events (Relkin et al., 2020). Further suggestions for teaching CT concepts such as algorithms, decomposition, sequencing, and patterns (Lee et al, 2022); communication and collaboration (Critten et al., 2021); problem-solving and debugging (Relkin et al., 2020) can be taught using unplugged activities that are '… *concrete, hands-on, and play-based'* (Lee et al., 2022, pp 4). Activities such as basic cooking (icing biscuits or pizza-making), bathing a doll, building a Lego castle, and getting dressed in the correct order can all be utilised in guided play to encourage the children to sequence, evaluate, problem solve and debug (see Critten et al, 2021). These activities provide an introduction before asking children to create their own sequences of movements, to encourage directionality or distance and can be/ and are already taught in early years, but not explicitly for CT development.

A number of CT skills are already being taught in preschools with older children aged 5-6 years, especially in the field of spatial thinking (Palmer, 2017) with the use of programmable manipulatives such as toy robots (Bers et al, 2019) and other digital toys (Wang et al., 2021). Palmer (2017) suggests that concepts such as orientation skills; counting especially regarding one-to-one correspondence; an understanding of symbols (the arrows on a robot); and communication and collaboration can all be taught with the use of a robot and guided interactions from a teacher. Robots such as the Bee-Bot have been utilised in a number of studies involving preschool children, but these can be problematic for very young children (Bakala et al., 2021). One of the difficulties these authors identified is the use of physical buttons to program the robot which seems to be very accessible for young children, but it involves directionality and the use of left and right commands which young children may not have mastered. Critten et al. (2021) suggest that teaching Bee-Bots might be better suited to those over four years of age and generally the majority of the research articles involving robots such as Bee-Bots are for children of 4-5 years and over. Papert and Harel suggests that the use of robotics in a creative and '*constructionist*' process can encourage children to build their own games and projects and evaluate and amend, especially in a communicative and collaborative environment (Papert & Harel, 1991, 2002).

5. Approaches to assessing Computational Thinking in the Early Years

An important aspect of teaching CT skills in the early years is assessment, both of the lessons themselves and of the children's understanding and progress, and these are always related (Zygotsky et al., 1980).

Assessment in the preschool years is mainly carried out by observations in the classroom, within small groups and individually in order to establish the children's knowledge and understanding. Not only are the staff interested in seeing progress in specific subjects, but they are also interested in children's social development particularly in their interactions with their peers, adults around them, and their play with toys (DfE, 2022). In preschool establishments, staff often show children's progress with a collection of photos, examples of work and descriptions of behaviours and these are presented together in a Learning Book or journal. These can be viewed at school by parents or, more commonly, digital formats can be readily shared throughout the year, for example, using apps such as Marvellous Me or Tapestry.

Early years education adopts a holistic approach by working on and with the whole child (Brassard & Boehm, 2007; DfES, 2024). Assessment of such holistic learning, therefore, requires a multi-faceted evaluation (Allsop, 2019), and assessing young children's CT progress is likely to serve multiple functions. Specifically, teachers will understand the needs and strengths of children across developmental areas and accordingly plan instruction and other forms of early intervention; adjust learning activities, monitor children's progress, and set reachable goals for each individual in the classroom; evaluate the effectiveness of applied activities and intervention programs; evaluate their own teaching for the purposes of accountability (Brassard & Boehm, 2007).

Because there are no statutory guidelines for CT assessment, researchers have mainly developed their own assessment frameworks (Shute et al., 2017) and these assessments are often based on a breakdown of the skills needed to perform a task such as on Scratch or Alice software (see Allsop, 2019). However, this type of assessment is designed for older pupils who are using computer screens. So how can teachers assess very young pupils in preschool establishments? Assessment criteria in the EYFS Baseline Assessment does hint at CT themes. In Language for communication and listening, 'Talks activities through, reflecting on and modifying actions' is logical reasoning. Linking sounds and letters, 'Joins in with rhyming and rhythmic activities' links to pattern recognition. In Shapes, space and measures '*Describes shapes in simple models, pictures and patterns,*' can look at pattern recognition again. In Knowledge and understanding of the world '*Shows curiosity and interest by exploring surroundings'* can be great examples of utilising maps, navigation and landmarks. Creative development encompasses many of the unplugged activities available as the children have creative freedom throughout the structured play activity and this can allow opportunities for child/adult conversations (ELG Listening, Attention and understanding, page 11, DfES, 2024).

Given that there are no official guidelines, teachers could use an evidence-centred design [ECD] (Mislevy & Haertel, 2007; Snow et al., 2019) based on children's play activities in the classroom, for example bathing or dressing a doll; doing simple cookery; or following a route in the playground. One of the aspects of ECD is assessment-designing in which teachers provide the content, and focus on the student to observe what skills they are developing. To do this the teacher has to establish how skills are measured using an evidence model, and as these have not been previously measured, teachers will need to devise their own criteria. Additionally, teachers can use a task model using situations to elicit behaviours, for example dressing up, or setting a table and monitor and assess children's skills from their play (Clarke-Midura et al., 2021).

Utilising many of the areas of learning from Table 1, a scheme of work/ lesson plan was designed for an activity (icing biscuits) for 2–4-year-old children at a coding club (Hagon et al, 2020, see Figure 2). The scheme of work contains CT concepts, learning outcomes and suggestions for vocabulary; while the lesson plan section contains lists of equipment, and assessments of progress using an 'I can…' approach (Lilly et al, 2014). In many schools, there are facilitated activities where children use self-assessment and peer assessment so that the onus is not always on the practitioners to determine progress. However, as mentioned earlier, there must be an element of scaffolding to the learning to ensure that the children are secure in the most basic knowledge of the practitioners' expectations. The goal is to set the children up for success with '*hard fun'* (Papert, 1988) but to ensure this, teachers need to create activities in which children feel secure in their abilities (Smiley & Dweek, 1994), and create self-assessments in which individual children can identify task-achievement (see Figure 2, Assessment/ Progress).

Icing a Biscuit			
CT themes Algorithms Sequencing Debugging Resilience **National Curriculum Themes** Maths English Creative expression	**Tasks for teacher** 1. Intro – what is an algorithm? 2. What equipment do we need? 3. Provide ingredients 4. Ask children to measure ingredients using spoons 5. What do we do now? (sequencing) 6. Debugging (collaboration) 7. Make the icing and coat the biscuits 8. Review the learning outcomes	**Equipment required** Large bowl or individual bowls Spoons of different sizes Distraction equipment, e.g. toy, hairbrush, book Plain biscuits Icing sugar Jug of warm water Named paper towel	**Assessment/Progress** I can pick the correct equipment I can use the correct equipment I can measure ingredients I can give instructions I can follow instructions I can collaborate with others I can spot mistakes I can fix mistakes I can sequence the task
Learning Outcomes • To learn about algorithms • To listen to instructions • To follow a task • To identify and correct errors	**Key Vocabulary** Algorithms Debugging Sequence Sequencing	**Additional resources** Grid for sticking pictures (3 or 4 grids) Pictures to sequence the task.	**Teacher/TA assessment** Emerging (Baseline) – needs 1:1 help to complete task. Expected – child can do all above but with some prompts from adult Exceeded – independently completes task **Score** 1: Emerging skills 2: Expected – work independently 3: Exceeded (greater depth) – can transfer skills

Figure 2 Scheme of work/ lesson plan for a CT skills activity in preschool

This lesson plan (Figure 2) contains much of the information needed to both teach and assess a common play activity but also includes a CT skills focus. The plan includes CT themes; the tasks for the teacher or parent (assessment design); the equipment needed; the learning outcomes; the key vocabulary (which may be used depending on the age of the children); and additional resources needed. The lesson plan also gives a breakdown on the skills needed to complete the task (an evidence model) which can be assessed by the teacher or can be used by the children themselves to help them self-assess. If evidence of the children's abilities is required for the children's reports, then a paper activity can be completed after the task in which children are asked to sequence the order in which they completed the activity. Figure 3 shows a two-year-old icing a biscuit followed by another child in the group sticking four pictures showing the order in which the girls made icing and iced a biscuit (Hagon et al., 2020). The pictures showed a box of icing sugar, a jug of water, the icing mixture, and the icing on the biscuit.

Figure 3: Icing a biscuit activity in a group of two-year-old children: the four pictures had to be stuck in the correct order to assess whether the children remembered or could work out the sequence of the activity (Hagon et al., 2020)

In Hagon’s article (2020), the children were encouraged to communicate collaboratively, making suggestions for the equipment used, the sequence of the activity, and to debug if there were any errors (e.g. the icing was too runny). The activity also covers a number of the early learning goals: Maths as the children measured out spoonfuls of the icing sugar and the water; Physical Development, as the children used fine motor skills to complete the task; Communication and Language skills, as the children had to follow instructions, interact with each other, and ask and answer questions; and PSHE, as the children had to self-regulate their behaviours and build relationships within the group.

This activity as well as others, e.g. getting dressed or bathing the doll, was used in research on preschool coding clubs by Critten et al (2021) in which the children were assessed using a three-point scale similar to the one displayed in Figure 2 Teacher/ TA Assessment, and is often used in the early years foundation stage (EYFS) assessment reports in England at present (DfES, 2020). These have now been updated (see DfES, 2024) but the wording is very similar, and the scoring is still relevant.

Some educationists may disagree with the idea that CT themes could be built into the play activities in early years establishments, particularly that they should be assessed as other subjects on the curriculum. However, the teaching and assessment of CT skills can be organised within schools by the subject coordinators, the Ed. Techs, particularly within reception classes with children aged 4-5 years. A gradual build-up of CT skills could aid the development of computer science in later years but may also help to develop other associated skills in STEM subjects.

6. Discussion

This theoretical article was designed to help and encourage teachers and other practitioners to understand the importance of developing CT concepts in an increasingly digital world in which most children have already become consumers. While programming and coding in elementary forms are already part of the curriculum in schools around the world, researchers have suggested that teaching the basics of CT could encourage children to plan and think more explicitly rather than just take part in play activities.

One of the aims of this article was to show a way in which CT activities can be incorporated into the early learning guides in the English National Curriculum, so that preschool teachers were not expected to add to already crowded curriculum (Wang et al., 2023). Examples of CT concepts shown in Figure 1 are addressed by researchers such as Lee et al.., (2023) who suggested appropriate activities such as '*puzzle, block play… separate steps of an activity such as handwashing*…' but did not elaborate in how these tasks could be utilised in lessons or how they could be assessed. Similarly, Saxena et al., 2019, suggested that pattern recognition could encourage children's sense of order (identifying and sequencing) but did not give guidelines to teachers in how this could be done. The question here is not just providing these activities but how they can provide a base in which CT is introduced, and this calls on the skills of the teaching staff to talk to the children and question them about their ideas in order to focus on CT concepts. In other words, these concepts need to be taught explicitly within those play situations, and in such a way that children can learn individually or within group situations (Vygotsky et al., 1980) promoting communication and collaboration which is one of the key targets of the early learning guides.

One of the problems identified with incorporating CT into the early years guides is that teachers often do not have the training or the motivation or indeed the awareness of how these concepts can improve or encourage children's planning and thinking skills (Arfe, 2019). Introducing these concepts are said to be fundamental in teaching computer sciences in later education (Ciftici et al, 2019), and a number of teachers after undergoing training understood how CT could be introduced in other areas of the curriculum (Cimsir et al 2024; Dong, 2019). Ideas for subject cross-overs can be seen in Table 1, where subjects like pattern recognition and sequencing already are part of the ELG, but outdoor activities such as in a playground, nursery garden or forest school can be utilised to encourage the children to learn direction, route-making and landmarks which will aid them when working on software such as Scratch (Critten et al., 2021). These unplugged activities do not require expensive hardware, or even robotic toys, as CT concepts can be encouraged with basic classroom equipment or paper and pencil tasks (Messer et al., 2018), however, they do require planning so teachers need to take time putting together their ideas into project schemes and lesson plans such as the one in Figure 2 (see Dong, 2019).

The other aim of the article was for the assessment of CT and if children are able to understand the basics of CT concepts. Using concrete tasks and appropriate play activities will help children to develop an understanding of the concepts alongside the ELG targets in Table 1 and teachers can communicate with and question individual children and in groups to both teach and assess children's progress (Vygotsky et al., 1980). Utilising Allsop's principles of using the breakdown of the tasks as a way of assessing children's understanding of the individual steps (Allsop, 2019) the lesson plan in Figure 2 gives examples of assessment of progress using the 'I can…' method (Lilly et al., 2014). In this way teachers can mediate by supporting students in their learning and by encouraging them to identify and find solutions when problems arise (Wang et al, 2023).

7. Conclusion

At present, there is a mismatch between researchers who suggest that CT should be part of the Early Years Framework; many teachers who know very little about CT skills; and UK government guidelines which ignore the early development of CT skills for this age group. CT is referenced in other areas of the national curriculum in later years of a child's academic journey but in the Early Years Framework, there are many CT themes that can be/ are already looked at but not necessarily expanded upon to allow a more in-depth introduction for children.

There is a huge opportunity to embrace CT concepts in early years education and align them with the core national curriculum areas to avoid duplication of effort and overwhelming workloads. If the activities are taught in a similar vein to the basic lesson outlined in here, the assessment opportunities present themselves very easily for teaching staff. Children and staff then have clear expectations of the baseline of knowledge in CT and ultimately computer sciences, and a pathway to encourage children to progress in their studies. With these skills being taught to children at the ages of 2-5 years, we would hope that these transferable skills become intrinsic elements of their personalities which will help them as they journey through their academic life and beyond to enter a world rich in STEM experiences and potentially careers.

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