Minding the Gap. Proposing a Teacher Learning-Training Framework for the Integration of Robotics in Primary Schools

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Abstract. Notwithstanding the hype surrounding the enthusiasm and rush that characterises the employment of robotics in formal educational contexts, their use is described as nothing less than fragmented. In the circumstances that processes of adoption and application of digital tools are clearly outpacing their accommodation and enactment in formal educational settings, a teacher-training framework for the integration of robotics in primary schools is being proposed.

Anticipated to be editable in context by teachers, a mediating tool whose actions are defined by the Activity Theory is presented to provide a framework for activities, aims, learning outcomes and suggestive complementing hardware. Thematically built around a constructionist approach, and having a long-standing tradition in early childhood education, it should simultaneously enhance the student and teacher learning experience towards robotics in a meaningful manner.

Keywords: activity theory, constructionism, learning guidance, project based learning, robotics, teacher training.

> *Some of them built airplanes, some of them built guitars. They worked on projects. And everybody who saw this was staggered at the difference of the energy that they showed there – the kind of involvement, engagement – […]. I think that this project that we could set up allowed some of them to get a new sense of themselves as learners*

> (Papert, 2001)

Introduction

When Palfrey and Gasser (2008) stated that: "No generation has yet lived from cradle to grave in the digital era" (p.3), they were succinctly reflecting on the rapid changes that digital technologies are bringing about across all aspects of contemporary society.

The NAEYC (National Association for the Education of Young Children), in conjunction with the Fred Rogers Centre for Early Learning and Children's Media (2012) tend to be more drastic because they refer to the digitally catalysed change as significantly disruptive in part to the shift from oral to print literacy or from the written to the printing press. Meanwhile, as processes for adoption and adaptation towards digital technologies have become suggestive of digitally mediated learning within formal educational landscapes, we are confronted with the reality that while schools are not immune to change they also respond to it relatively slowly (Facer, 2012). "Everything else has accelerated but schools have not" (Rosenstock, 2014). It is also common knowledge that digital technologies are developing at a much faster rate than their acceptance and enactment in the classroom. Yet, observable resistance from the teachers' side (Fullan, 2001) cannot just be attributable to a form of opposition but rather to a tangible gap between wishful thinking and what can in reality be achieved. In the meantime, hardware, initially in the form of desktop computers and now increasingly flexible handheld devices that include smartphones, tablet PCs and lately electronic learning toys, are finding new audiences even within groups of young children. Instinctively, a challenging question that arises is how to define and design developmentally appropriate activities and content for children of different ages (Bers, *et al.*, 2014). Without referring to any specific digital technology the NAEYC (2012) and other writers (Fullan and Langworthy, 2014; Pritchard 2007; Somekh, 2007) acknowledge the potential that digital technologies hold because they can think it can support and complement innate aptitudes that digitally competent young children already embrace. Therefore: "Technology and interactive media are here to stay" (NAEYC, 2012, p.2). This succinctly wraps up the concern that schools face. Notwithstanding the conceived potential that such technologies embrace, unless they are inherently integrated by the teachers themselves as a natural part of the teaching and learning process, then the expected digitally mediated learning outcomes cannot be achieved. Ihde (1993) suggests that, if technologies were merely objects totally divorced from human praxis then there would be so much 'junk' lying about and if we expect that the wishful thinking that defines a technology can create its indispensability (Castells, 2000), then, if technology in schools is not used with powerful teaching strategies, it will not get us very far (Fullan and Donelly, 2013). Sheninger (2014) anticipates that soon the first of the digital natives will be occupying teaching and key administrative positions in schools. Hopefully this should bring about the much-anticipated digitally acquired change. But one must not disregard that there are teachers who, because they do not know otherwise, are still tuned (if not clinging) to what Hargreaves (1996) refers to as crumbling edifices of industrial models and rigid bureaucracies that isolate classrooms and compartmentalise teaching to out-dated career structures.

In face of such issues, this paper has been written with the premise that notwithstanding the enormous learning potential underlying the field of Robotics in education (Yiannotsou, *et al.*, 2016; Bers, *et al.*, 2014; Mitnik, *et al.*, 2009), the area still presents a fragmented scenario with many trying to adopt robotics with no clear continuation (Yiannotsou *et al.*, 2016). In this case the question is not how to include robotics and ICT into the classroom because their presence is getting relentlessly stronger. The issue here is how to engage teachers and students and again, teachers, in meaningful activities that combine robotics to already familiar scenarios. As indicated by Jacobs (2014),

rather than looking for a comprehensive substitution of traditional learning methodologies with novel digitally enabled pedagogies one should look for an intersection and fusion of old with the new.

Subsequently, provisions for broad teaching and learning guidelines, evocative towards a generic plugin that can be employed in context of various specific learning situations will be presented. This is achieved by tapping into notions of human-computer interactions such as the activity theory (Kaptelinin *and* Nardi, 2006) and the theory of expansive learning (Engestrom, 1987), and merging them within areas of learning theories and pedagogy (Pritchard, 2007; Boss, 2015). In the process, teachers are provided with a springboard grounded within the four basic tenets of constructionism (Bers *et al.*, 2002) and project-based learning (PBL) that can potentially introduce or launch them further into the field of robotics as a constituent component of technology enhanced learning practice in primary schools.

This write-up is therefore structured as follows:

- Firstly, a portrayal of the atmosphere that has incentivised this paper is provided.
- This is secondly followed by an account of the underlying theoretical review. In this case, the Activity Theory is envisaged as a suitable theoretical lens that can define teachers' actions to ICT. This sets the conceptual foundations that will motivate the course of action into applied computational thinking within Constructionism and Project Based Learning.
- Thirdly, a generic teacher-training framework composed of two dimensions: a Guiding Checklist for Best Practices, and, an Activity Plan Template based on Aims, Learning Outcomes and suggestive accompanying hardware, is provided.

Underlying Motivations

This write-up originates in response to the requirement of activities underlying the implementation of an Erasmus+ KA2 initiative on Robotics for Primary Schools. The partnership enterprise is identifiable as: 'Robotics for Primary Schools in the 21st Century', in short, Robo21C. The initiative was composed of a multinational consortium of schools, training centres for robotics and universities. In alphabetical order these included: Denmark, Lithuania, Malta, Spain and the UK. Details for each participating partner may be found at the end of this article.

Thus within a framework that catered for diversified geographical locations, varied cultural provenance and academic backgrounds, an overarching aim was therefore directed towards the provision of concrete and contextually meaningful routes that different teachers could possibly follow and employ in context. The activity here involved the setup and development of a teacher-training framework that teachers teaching different year groups in primary schooling could adopt within their classroom. Subsequently, by harnessing 21st century skills (Eguchi, 2016; Rotherham and Willingham, 2010), the final outcome was taken to contribute towards the field of emerging digitally motivated pedagogies. Special attention was given towards the initiation into and the facilitation of the use of robotics in the classroom. In the process a merger of robotics with already fa-

miliar concepts that teachers already embraced, was envisaged (Pritchard, 2007). Within a constructionist framework for mediating learning with robotics, it was anticipated that participating teachers would gain or improve their insights towards the area by fostering dynamic learning environments and harnessing tacit pedagogical knowhow to develop novel complementing modalities for learning.

Rosenstock (2014) considers that as teacher-student partnership for learning becomes prevalent over an approach inclined towards the quality of content delivery, then technology use in education becomes more meaningful. Accordingly, in this initiative, the outcomes for the teaching/learning framework were envisaged as means for guiding teachers to design learning scenarios meant to empower pupils aged between 4 and 12 to engage in computational thinking skills through the mutual application of fundamental 21st century traits such as collaboration, communication, creativity, critical thinking, decision-making skills and a flair for entrepreneurship. Specifically, through: "[…] a model of learning partnerships between and among students and teachers" (Ibid. p.2, 2014), the move seized upon an inclination away from content delivery to technology-enabled teaching strategies that support students' mastery of required curricular content. It was therefore presumed that as pupils become more digitally literate and competent, i.e. able to use digital technologies, express themselves and extend their ideas through ICT, then they would also become competent and receptive towards future workplaces as active participants in the digital world.

Theoretical and Conceptual Foundations

As the name of the theory reflects, Activity Theory (AT) focuses on those emergent properties enacted and manifested 'only' when, an activity between two entities referred to as the subject and object is taking place (Leontiev, 1979). Blin and Munro (2008) consider activity systems as characterized by contradictions that invariably motivate innovation and change (Engestrom, 2001). Over time Leontiev's concept of an activity has been further developed by Engestrom (1987, 1999) to be integrated in Vygotsky's theory and giving rise to a theoretical framework referred to as Cultural-Historical Activity Theory (CHAT). Within a Leontievian perspective, activities arise in response to motivations for subjects, exemplified by individuals or groups, to bring about an intentional change to a specific object that can be an artefact or a specific circumstance (Blin and Munro, 2008). Based upon intentionally mediated actions, the activity is therefore seen as the most important component in the subject-object relation.

AT has nowadays been recognized as being useful in defining, analysing and therefore interpreting implemented transformations of collective practices in organisations (Karsavvidis, 2009). Given the expectancy underlying a digitally motivated change, the application of AT as a theoretical lens for analysis becomes particularly handy in the study of ICT in formal educational settings. In context of this write-up this includes the deployment of robotics in primary schools with a foresight of enacted activities that arise during the implementation process. As depicted in Fig. 1, applying AT's taxonomy would therefore designate the 'teacher' as the subject and, the 'student' and 'the learning of the student' as the object.
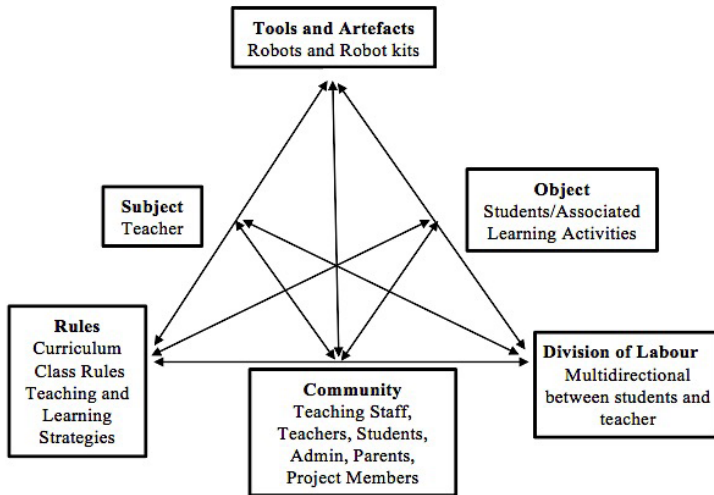
Fig. 1. Taxonomy of Action Theory for Robotics (Karasavvidis, 2009).

The mediating element in this case would be the availability of learning strategies based on robotics. These activities will be embedded in a thematic PBL strategy that compliments the curriculum and which the teacher is already familiar with. The 'activity' will invariably be grounded within a constructionist approach that actively supports student engagement while allowing time for the teacher to learn and grow in the field of robotics as the learning process unravels. The 'rules' include the curriculum, instructional rules, classroom rules and scheduling.

Incidentally, it is anticipated that nascent enacted activities during the implementation process can be suggestive of a sudden or formidable change in the modalities of teaching (Brikell, 1964). Albeit defining such a drastic change or disruption in teachers' modus operandi as a source for resistance, it can also be envisaged as a step closer to achieving the much required transformation that digitally mediated technologies still have to bring along into formal education contexts. The Oxford Dictionary (1996) defines 'disrupt' as to: 'interrupt the flow of continuity' and 'separate forcibly'. In this case, by disruption in teaching and learning processes, I am making reference to a serious transformation in teaching methodologies that focus on activities uniquely achievable through robotics. As Burbules and Callister (2000) imply with respect to elearning and in their case, virtual worlds, I believe that there are certain unique learning opportunities and transformations that can only be created within their respective learning environments. Taking it from Laurillard (2007) a common mistake in the adoption of digital technologies is that:

> *"[…] we tend to use technologies to support traditional modes of teaching-improving the quality of lecture presentations using interactive whiteboards, making lecture note readable in PowerPoint and available online […] all of them good, incremental improvements in quality and flexibility, but nowhere to being transformational"*

> (Laurillard, xv, 2007).

At its core the issue may be more intricate than it seems. Some more obvious sources for resistance include lack of hardware, reduced skills and familiarity with equipment, limited time and a wider sense, compatibility issues (Karasavvidis, 2009; Cordic *et al.* 2007; Cuban, 2001). In this case compatibility goes beyond concerns related to the diversity of software and hardware platforms. Olson (2000) states that when a new technology is introduced in the classroom it must compete and find space within other resident technologies. Nowadays besides tables and chairs; these include Interactive Boards and Screens, docking stations and computers that teachers have already adopted, adapted and endorsed with routine and embodied values of work being performed. Subsequently as any new technology will be 'domesticated' in line to embodied routines (Ibid. 2000) it might not achieve its transformable qualities. Cuban (1993) asserts that the overhead projector was readily integrated into existent teaching practices because rather than challenging what was being done it was actually enhancing it. On the other hand, if one considers interactive screens, transferring what is on the book onto a screen will never elicit the underlying transformative potential that can be achieved with such technologies. The same argument can be drawn up for robotics. Unlike screens; that tend to be akin to resident and familiar technologies such as the conventional board; introducing robotics in their anticipated ways may not be that straightforward, not unless their transformative potential is embedded within already familiar transformative practices like PBL. This becomes suggestive of a teacher professional development program grounded within a framework whereas understanding takes place with existing, understood and therefore resident schemas (Piaget and Inhelder, 1969; Johnson-Laird, 1983; Holland *et al.*, 1986; Pritchard, 2007). If meaningful learning requires active engagement in authentic learning tasks (Jonassen, *et al.*, 2008) then the accommodation of robotics as a new internal activity will be stimulated through its application in PBL as the familiar external activity teachers are accustomed to, subsequently bolstering the continuum between behaviour and consciousness (Leontiev, 1981).

As expressed in Fig. 2, the flexible nature inherent of PBL caters for subjective designer's interpretation allowing the way forward to take place in any direction. Bers *et al.* (2002) state that when faced with the challenge of using computers in class, many teachers revert to an instructional kind of approach. Instead, reflection through PBL activities should allow teacher to migrate from being consumers to becoming designers of technology rich curricula.

> *[…] in early childhood education there is general agreement about the efficacy of 'learning by doing' and engaging in project-based learning. Computers can complement these already established practices and even extend both children's and teacher's experiences to 'learning by designing'.*
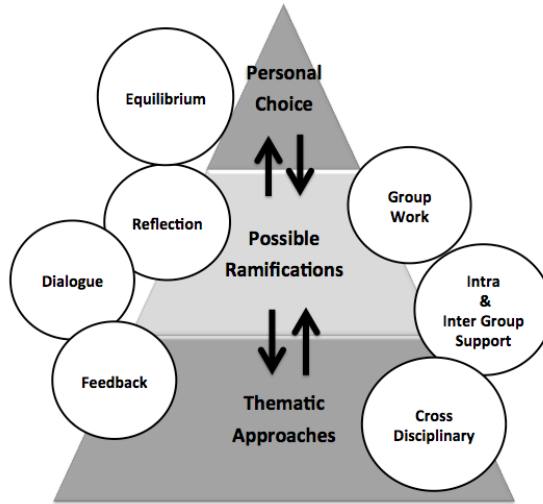>
> (Bers *et al.* 2002)

Fig. 2. A model for Project Based Learning.

Thus, there are several provisions that will render PBL useful as a contextual backdrop along which a robotics teachers' training program can be designed, such as:

(1) PBL promotes teaching and learning models for both teacher and student. Students gain knowledge and skills by working for an extended period of time to investigate and respond to a complex question, problem, or challenge. For the teacher, the element of time is also favourable as it gives him/her space to reflect on outcomes while experimenting with robotics in class. Bers *et al.* (2002) state that while teachers may know how to use computers there still is that lack of true technological fluency or naturalisation such as that for instance observed in writing. In this case we are so naturalised to the act of writing that we rarely focus on the pen but on what we are writing. Once a technology disappears in the background, we stop worrying about it and focus more in what it does (Davidson, 2012). Subsequently, time, as a component of PBL, will cater for better adaptation through experimentation and therefore on gained experiences, ultimately maturing in the enactment of tailor-made activities that make use of robotics. PBL activities will therefore allow teachers to become active designers of meaningful activities where they have the opportunity of blending new materials with familiar ones in personally measured cumulative steps that build up towards thematically based learning outcomes.

(2) PBL can engage and complement robotics related student-driven inquiry based methods, providing rich grounds for authentic problem solving activities (Boss, 2015). Bers *et al.*, (2014) claim that substantial research in implementing robotics in schools has already shown that four to six-year-old children can build and program simple robotics projects (Kazakoff *et al.*, 2012; Wyeth, 2008; Cejka *et al.*, 2006; Bers *et al.*, 2002; Perlman, 1976.). Additionally, for teachers' robotics can provide a fun and playful way of transforming academic content in meaningful projects (Bers *et al.*, 2014; Bers, 2008).

Incidentally, traits that improve motivation, engagement, deeper understanding of academic content and enhanced problem-solving skills (Boss, 2015; Finkelstein *et al.*, 2010), constitute the foundations for the 'new pedagogies'. Rosenstock (2014) succinctly defines these new pedagogies as: "[…] a new model of learning partnerships between students' and teachers […] enabled by pervasive digital access" (p. 2). In the realms of Technology Enhanced Learning the discipline of robotics in education is still young (Yiannoutsou *et al.*, 2016; Benitti, 2012) but through PBL, both teachers and students can share, learn and mature together towards a more meaningful and authentic teaching and learning experience.

(3) PBL complements the basic tenets of constructionism that Bers *et al.*, (2002) claim to: "[…] have a long-standing tradition in early childhood education" (p. 123). These include: learning by designing, using concrete objects to build and explore, the identification of ideas (powerful ideas) that are personally significant and, the place of self-reflection into the learning process.

(4) Ultimately, besides being multidisciplinary in nature, Robotics happens to be at the heart of constructionist philosophy (Yiannotsou *et al.*, 2016; Lindh and Holgersson, 2007).

In the next section, a teacher-training framework, whose actors' actions are defined by the Activity Theory as the theoretical lens, is suggested. Grounded within the parameters of Project Based Learning, it is specifically designed to fulfil a constructionist approach that complements the use of robotics in educational settings (Yiannoutsou *et al.*, 2016; Bers, *et al.*, 2014; Mitnik, *et al.*, 2009). It is reckoned that as the framework crafts and monitors action, reflection gained through implementation should consequently give rise to a recursive dialogue whereas experience gained will subsequently revert back to adjust and update theory.

The Teacher-Training Framework

As expressed in this section, the Teacher Training Framework is composed of two parts:

(1) A set of criteria embedded in the Activity Theory, shaping the activity that will aid implementation of robotics in meaningful learning scenarios.

(2) An activity template, which grounded within a constructionist framework, becomes suggestive of learning outcomes that promote user-initiated activities.

The framework should therefore be taken as a point of initiation underlying the setup and presentation of a generic and editable teacher-training framework that motivates the integration of robotics in primary schools. The framework is editable because while structurally designed to guide users in their planning and execution it does not ignore users' own professional interpretation and therefore the potential and initiative to revise and adapt the tool in context. It is therefore envisaged to act as a facilitating mechanism in the process of reconciliation between the contextual curricular requirements, professional teaching experience, latent teaching resources and digitally mediated pedagogies that will integrate robotics in teachers' teaching methodologies.

Checklist for the selection of best practices

Defining Criteria	Inferences and Rationale
Context	• Venue of the activity. Provision of information of the place and conditions in which the activity will be performed. Will it be in class, outside, in the country-side, a visit to an educational institution? • The Community/Division of Labour. Who will be involved in the activity? What will each and every member of the learning community be doing? What specific tasks will the teacher and support teaching staff do during the activity? What will be the teacher's role: instructor, mentor, facilitator? • Students. Qualities of the participants that would motivate the type of activity chosen to include age group, gender, academic motivation and inclination.
Purpose of Educational Activity	• Pedagogical Rationale and Purpose underlying the activity. What are the aims, objectives of the activity? What qualities will the student develop? • Nature of Activity. Is the activity subject oriented or is it a cross disciplinary approach? Will the activity include coding and development of computational thinking skills? Will the activity be based on instruction, self-expression or discovery-based learning? Will there be one prescribed activity for each student to use a robot or will the use of robotics be part of a group activity? How will group dynamics be set up? Will students in the group contribute towards a common task or will each and every student have a set task that will contribute to the group's final outcome? How integral will be the use of robotics in the task being given? • The Motivation Underlying the Activity. Will the students be introduced to a new concept facilitated through the application of robotics? What will be the learning outcomes? What type of skills will the students develop? Will the activity accommodate soft learning skills such as social skills, the handling and use of blocks, dexterity and computational thinking skills such as coding or cognitive skills such as reasoning intuition and other higher order thinking skills? Will the activity relate to the student's everyday experiences? Thus how meaningful will the activity be?
Resources and Tools	• Equipment. A note of all equipment including digital tools that will be availed of by the students should be recorded. In this case the compatibility of equipment to the students' aptitudes should be taken in consideration. Will robotics use be on its own accord or will it involve other technology enhanced learning tools such as the combination with tablet PCs, interactive screens/interactive board and/or use of ancillary equipment in STEM such as digital microscopes? In this case what methods that introduce students to new tools have been considered beforehand?
Assessment of Outcomes	• Adaptability. Did pupils adapt easily to the robotics induced activities? Were there any difficulties/hazards when using robots? • Activity Output and Reflection. Were curricular goals achieved? What have you learned? What have the pupils learned?
Sustainability	• Expenses. What expenses were incurred? Will the same methodology induce the same expenses, more, or less? Which resources can be used utilized for the same and/or successive activities?

Proposed Activity Template

A guide to introducing robotics within traditional and other digitally mediated learning activities in the early childhood classroom is thus being proposed. Based on four basic tenets of constructionism as expressed by Bers et al (2002) these include:

(1) Learning by designing shareable and meaningful initiatives.
(2) Making reference to tangible instances to explore the world.
(3) Identifying personally and epistemologically significant powerful ideas.
(4) Self-reflection as part of the learning process.

Prerequisites for teacher

(1) Is familiar with hardware.
(2) Knows simple coding.
(3) Pedagogically sound and working knowledge of Technology Enhanced Learning and Digitally Mediated Education.
(4) Is familiar with Project Based Learning activities.

Things to take in consideration before implementing robotics tools.

(1) Robotics can give rise to multimedia activities and are therefore multisensory. Robots may speak, make sounds, or flash with lights and colours in response to the environment as per instructions.
(2) Robots lend themselves to do-it-yourself activities:
   ● Enhancement of creative thinking, reflection and decision making skills.
   ● Robots need the ability to follow programmed instructions and not just be controlled remotely and interactively even through the Internet, a computer or handheld device such as a smartphone or tablet PC.
   ● Making best use of hardware that pupils may already be familiar with. Giving an extra dimension of learning to already familiar devices.

Aims of Proposed Framework: 5 Interrelated Dimensions.

(1) Elucidation of ways of making learning robotics fun.
(2) Search effective way of introducing programming to students.
(3) Provision of skills related to future employment.
(4) Suitable exercises for mixed ability classrooms.
(5) The demystification of a complex technology through principles that employ scaffolding methodologies.

Dimension 1. Children find it fun

There are several competitions for a range of age groups that can channel competitive instincts in a positive way. For example, asking children to build a robot from a Lego WeDo set and then running a race to see which robot goes fastest works well.

Embed Bee/Blue Bots in Board games such as Monopoly utilising bots to move around the board.

Aims	Learning Outcomes	Indicative Equipment/Methodologies
Learning through play. Game Based learning and Gamification	I am able to work in a group.	Blue/Beebots
	I can be adaptive in competitive situations	Bot races
		Embedding Bots in board- games/quizzes
	I am able to read and add numbers	LEGO Mindstorms
	I understand that I can win and lose.	Show and Tell activities
	I am capable of talking about what 'we' did.	
	I can reflect on outcomes.	

Dimension 2. Effective way of introducing programming to students

By having to control a physical robot and seeing what goes wrong, students learn what robots can and cannot do. They also learn the need for precise instructions.

Aims	Learning Outcomes	Indicative Equipment/Methodologies
I. Fostering Logical thinking	I know directions: Left, right, up, down	Sphero
	I know the Cartesian Convention: Up and right are Positive, Down and Left are Negative	Bluebot
		Bee Bots
		Tablet PC
	I know how to make/follow a sequence	Smart Phone
	I can evaluate and make a decision.	PC
	I can plan beforehand	
II. Encourage Problem Solving	I can create a shape	Sphero
	I can create a specific shape	Bluebots
	I am capable of finding my own solution(s).	Bee Bots
	I am capable of moving beyond what I have been taught to do.	Scaffolding Activities: construction of Models with:
	Create an open environment with multiple conclusions	i. Lego Learn to Learn ii. Lego Simple Machines iii. Lego WeDo
III. Learning Coding Skills	I can distinguish directions	BluBot
	I can recognise different colours to build sequenced 3D models.	BeeBot
		Sphero
	I can group similar objects together.	LEGO WeDo
	I can do simple coding through drag and drop programming interfaces.	LEGO Mindstorms
		Tablet PCs/PCs
		Application of Gamification principles

Dimension 3. Provides skills useful in future employment

Special reference is made to 21st century skills

Aims	Learning outcomes	Indicative equipment/Methodologies
Emphasising Key Competencies	I am able to work in a group.	Lego Learn to Learn
Communication	I can communicate what I have to say in a multimodal manner.	Lego simple machines
Collaborate Connectedness	I am able to read and write	Lego WeDo
Communities of Learners	I can recognise that different applications can converge through the use of one device.	Creation of in-group sequential Photostory telling (Collaboration)
Convergence		Creation of Classroom based digitally mediated storytelling (Communities of Learners, Connectedness)
Contextualisation	I understand what it means to work in a community of learners and network with others.	
Create		Scaffolding methodologies
	I recognise that I can do a lot with one device	

Dimension 4. Suitable for children with a range of abilities

One size does not fit all, thus applying scaffolding and differentiating approaches. Scaffolding a lesson: breaking up the learning into chunks and then providing a tool, or structure, with each chunk. Different pupils may achieve different levels or achieve the ultimate levels in different times.

Differentiation: the same chunks may be changed differently according to aptitudes

Aims	Learning Outcomes	Indicative Equipment/Methodologies
Embedding robotics in context	I know how to lead	Using Bee/Bluebots
Learn group dynamics	I am capable of following instructions in a group.	Sphero
Learn Specified Task management in chain of command.	I learn by helping others.	Smartphone/Handheld Device
	I learn by asking peers.	PC
	I can do simple programming	LEGO WeDo
	I can create a strategy.	
	I learn to work with others (Social skills)	

Example:

The 'Head Programmer' plans the next move.
The 'Code Writer' puts the command cards in order.
The 'Command Keyer' keys in the commands.
The 'Debugger' tracks where in the program the robot currently is and fixes any problems that arise.

Dimension 5. Demystifying a complex technology

Connect content with robots.
This can be seen as an ongoing theme in tandem to the other activities. Application of robotics in themes based in project based learning activities.

THUS:
Learning by doing

Aims	Learning Outcomes	Equipment/Methodologies
Applying robotics Activities in Context	I learn to build robots.	LEGO WeDo
Make Robotics accessible through contextualization	I build robots to help in specific tasks.	LEGO Mindstorms
Create solvable real world scenario problems that can be solved using robots/ programmable hardware	I use robots and programs to solve real worlds problems.	Tablet PC/Hand Held devices
	I collaborate with others to solve specific set themes.	
	I present in show and tell activities outcomes of projects.	
	I learn to build an artefact, test evaluate, refine and improve it	

Conclusion

In this paper, the characteristics of a tool designed to mediate between teachers' innate professional qualities and the meaningful deployment of robotics in primary schools has been discussed. Reference has been made to a pedagogical approach that, as it inclines towards project based learning, is catering for a common ground where complimenting characteristics for constructionism and robotics learning can bloom into meaningful learning experiences for teacher and student alike. Invariably designed in young but evolving flourishing research scenarios it is understood that as the framework model is adopted it is prone to be modified in context of use. This implies that the presented framework is in all facts a works in progress initiative. Undeniably its strength lies in the recursive dialogues that can potentially take place when after being deployed within targeted teacher circles the same teachers will be able report 'back to base' with new ideas and customisations.

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List of participating institutions in alphabetical order

Ermington Primary School, Ivybridge, UK.
Bohrskolen, Esbjerg, Denmark.
CEIP Oromana, Alcalá de Guadaíra, Spain.
Centro de Profesorado de Alcalá de Guadaíra, Spain.
Colegio de Educación infantil y Primaria Hermelinda Núñez, Alcalá de Guadaíra, Spain.
Lisodea, Alytus, Lithuania
St. Andrew's C of E Aided Primary School, Yelverton UK.
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