EdTech as an Empowering Tool: Designing Digital Learning Environments to Extend the Action Space for Learning and Foster Digital Agency

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Abstract. Educational Technology (EdTech) can be both empowering or constraining depending upon the underpinning design. Drawing from the experiments conducted as part of a large scale EdTech intervention in India, this paper shares qualitative findings on designing digital learning environments (DLE) as tools that empower the learner. Building upon the literature on digital agency and microworlds, the first section propounds that for EdTech to become an empowering tool the design of EdTech should expressly cultivate a learner's digital agency and extend the action space for learning. While digital agency encompasses aspects of competence, confidence and accountability; the action space for learning (ASL) is defined as a cognitive-pedagogic construct where learners operate. Subsequently, the paper outlines the key characteristics of EdTech that empowers, and shares research findings. It was found that when DLEs are thoughtfully designed to provide a manipulable action space in a microworld where learners can own the dynamics of the environment through variables and controls, then a learner's digital agency is fostered through the extended possibilities of ASL.

Keywords: Action Space for Learning · Digital Agency · Digital Learning Environment · DOER

1 Introduction

Digital learning environments (DLEs) are digital technology-based applications that provide a virtual environment for the teaching-learning process [1, 2]. These DLEs, also referred to as educational technology (EdTech) solutions, can be both empowering or inhibiting depending upon the underpinning design [3–5]. There is a plethora of research on the affective role of design in the efficacy and usability of DLE [1, 2, 4]. However, more often than not DLEs get developed for limited passive instructional purposes that encourage a transmission model of pedagogy where teachers direct learners

to progress linearly through different subject content. This kind of a design on the one hand undermines the possible transformative potential of technology [5–7] and on the other hand reinforces the perils and pitfalls of conventional didactic pedagogy. In order to meaningfully harness digital technologies for education it is imperative to consider the learning design aspects [3]. Because, the power of EdTech lies not in device but in design. Based on the ideas of manipulable "microworlds" [6, p. 120] and constructivist learning environments [7] we make a case for a learner-centered design of EdTech that empowers learners by providing a manipulation space and tools to extend the action space for learning. Subsequently, through the exemplar artefacts and research evidence from a large-scale multi-state, multi-partner EdTech intervention in India we demonstrate and argue that such an empowering EdTech design would foster learners' digital agency - an emerging 21st century capability. Finally, the paper concludes with recommendations for further research and a call to investigate potential of EdTech as an empowering tool by employing an action-oriented approach for teaching and learning.

2   Methodology

The objective of this article is to contribute first steps toward developing an eclectic model of EdTech as a tool to empower learners by drawing complementarity from the fields of learning design, learning sciences and educational technology. Situating the arguments for active and constructivist learning within the ideas of manipulable "microworlds" [6, 7] we seek to extrapolate the discourse in learning sciences literature on action-oriented peripersonal space [8] and "field of promoted action" [9] to construct a case for an action space for learning. Subsequently, drawing from the qualitative and quantitative research evidence generated from a large-scale EdTech intervention in India, we employ inductive reasoning to develop a case for an EdTech that empowers learners by fostering digital agency [10].

The design experiments were conducted by authors along with a team while designing the EdTech applications between the years 2016 and 2019. Qualitative findings are drawn from design-based research studies with teachers and students.

3   Towards an Action Space for Learning

3.1   What is Action Space for Learning?

Seymour Papert was an optimist, almost a utopian, about the transformative potential of computers and technology for education. However, he was categorical in how technology should and should not be designed for education. He offers the microworld as an interactive technology enabled learning environment where learners "become the active, constructing architects of their own learning" [6, p. 122]. He argues that in order to make a microworld an "incubator for knowledge" it is essential to provide a manipulable space which offers opportunities for "personal appropriation" and "owning the dynamics". Similarly, Jonassen [7] considers a manipulable space to be an essential characteristic of constructivist learning environments (CLE) where learners can conduct meaningful activities by manipulating the environment through objects, signs, and tools.

In the cognitive science literature on the action-oriented learning, Abrahamson and Sánchez-García [9] present field of promoted action as a social microecology in which a novice learner is presented with a specific motor problem as well as constraints. Such a field of promoted action can be used by educators to design and implement a non-linear pedagogy through ecological conditions, tasks, and resources to facilitate students' self-exploratory activity. Similarly, the literature [8] defines peripersonal space as a set of spaces/fields manifesting physiological or perceptual actions between objects and the body.
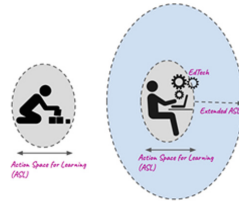

Fig. 1. Action Space for Learning – a cognitive-pedagogic construct which gets extended by an empowering EdTech

Thus, we propose (see Fig. 1) that the eclectic blend of manipulable microworlds and field of promoted action/peripersonal space leads to the conception of an action space for learning (ASL). The ASL is hence characterized by three features:

(1) manipulands - objects, variables, controls and tools
(2) action - an interactive learning activity
(3) action space – a field and boundary to operate within

Apropos to above, we suggest that such an action space for learning fosters digital agency. Provisioning of equitable opportunities to cultivate digital competence, confidence and accountability are essential elements of digital agency [10]. Consequently, in a DLE designed as an ASL, manipulands and opportunities for action help foster competence and confidence whereas the action space with controls and constraints compels learners to be accountable of their actions.

4 Empirical Context

This section discusses the salient features of design experiments towards an empowering EdTech.

4.1 The DOER Microworld – Lego Modelled Distributed Decentralised Open Educational Resources

While embarking on the initiative of the Connected Learning Initiative (CLIx) to demonstrate a model of "quality at scale" by leveraging EdTech, we wanted to learn from the history of EdTech – what worked/not worked, when and why. The literature tells us that

more often EdTech solutions take little cognizance of pedagogical nuances and continue to reinforce transmissive pedagogies and passive learning [5–7]. Papert [6] calls these as 'technocentric' approaches where *tech* drives the *ed*. Therefore, we began with *ed* i.e. educational considerations and developed a framework of three pedagogical pillars - authentic learning, collaboration and learning from mistakes - around which the entire intervention including the EdTech enterprise solutions were to revolve. These pedagogical pillars were rooted in the literature of active and constructivist theories of learning [3, 6, 7].

Grounded with the educational aspects of the proposed EdTech solutions, we adopted a lego approach of designing EdTech solutions [2, 11]. We analysed and borrowed the existing open-license solutions which complied with the pedagogical pillars. Consider these as *lego blocks*. Subsequently, we developed a flexible digital learning environment as a *lego board* which allowed us to create a mashup of various open-license, open-standards compliant learning tools. The resultant federated EdTech solutions stack is called a DOER - Distributed Decentralized Open Educational Resources which worked both online and offline to serve even in the internet-scarce regions. Importantly, following Papert's concept of microworlds, we introduced several manipulable affordances in the DOER such as - collaborative story making, sharable e-Notes, and Gallery to showcase artefacts. The federated DOER had dynamic math tools such as GeoGebra and Turtle logo, integrated SugarLab tools and a number of digital interactives such as Open Story Tool and simulations. Further, structured course modules were designed to leverage affordances of platform to achieve the pedagogical goals. Therefore, by design, the DOER encouraged interactivity, creation, collaboration and allowed learners to make mistakes in a manipulation space.

4.2   EdTech as an Empowering Tool - Extending the Action Space for Learning and Fostering Digital Agency

With thoughtfully designed EdTech and consciously provided affordances to extend the action space for learning we deployed the EdTech solutions stack i.e., DOER platform in more than 500 intervention schools between 2016 and 2019. What emerged was just phenomenal. Most of the students in the intervention were first generation learners and digital novices in secondary schools [12]. However, the design considerations that embodied the DOER platform and learner-centric features of buddy login, built-in mechanisms for feedback and multimodal content that encouraged a culture of sharing, seeking, giving feedback through a civilized digital discourse engendered an extended action space for learning where learner agency came to the fore (see Fig. 2).

The exemplar design features presented above demonstrate that thoughtfully designed EdTech can extend the action space for learning (ASL) and cultivate digital agency (DA) – an emergent 21st century capability. The ASL and DA are arguably peculiar to a digital learning environment (DLE) as against a physical learning environment (PLE). This is because the DLE posits unique affordances for teaching and learning due to its distinct media through which it operates [5]. Therefore, it becomes important to understand and perhaps redefine the notions of learning and action space for learning in this media and examine how a learner engages in this virtual space. Through the above examples we argue that DLE provides affordances for teaching and learning

that are unthinkable in a PLE thereby engendering a digital agency that operates in a DLE. Similarly, DLE could provide a field of promoted action which we call as action space for learning where a learner engages in perceptual and meaningful educational activities.
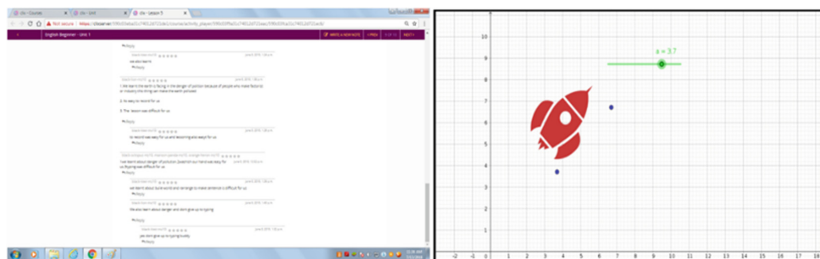

Fig. 2. (Left) First generation digital learners engaged in a civilized digital discourse through threaded discussion moderated by teachers; (Right) A young learner from disadvantaged background of slum created a rocket propellant using GeoGebra and exclaimed "Madam, you made me a scientist!", an exemplary case of EdTech as an empowering tool.

In the next section we present research findings of overall CLIx offerings including the aforementioned aspects of design and features of EdTech solutions.

5   Research Findings

The CLIx intervention used a design-based research framework [1] to analyse the efficacy and impact of EdTech interventions through base-line, mid-line and end-line surveys as well as a DOER platform data during phase-I of the intervention (2015–2019). The research findings [12] indicate that students made significant gains in basic and inter-mediate technical skills (significant at the 5% level) and application based technological skills (significant at the 5% level). Findings from a learning outcome study have shown significant gains among students in Mathematics (avg 7.16 points gain), Science (avg 13 points gain) and English (avg 2.12 gain in listening and avg 8.51 gain in speaking).

The opportunity to use the DOER platform in a computer lab has produced significant shifts in students' knowledge and competencies of basic digital skills (such as turning on a computer) and specific digital skills pertaining to the DOER action space of learning (ASL) and hence indicates fostering the digital agency (DA). Significant improvements were observed with respect to students' digital skills relating to extended ASL in the case of the student group that received engagement opportunities with the DOER platform compared to the external control group that did not have access to it.

6   Conclusion

Drawing complementarity from the fields of learning design, learning sciences and educational technology, we proposed first steps toward developing an eclectic model of designing EdTech as a tool to empower learners. Extrapolating the concepts of digital

learning environments as manipulable microworlds, we have propounded the notion of action space for learning (ASL) to foster learners' digital agency - an emergent 21st century skill. We argued that the design underpinnings of EdTech solutions make these tools as empowering or constraining. Through design-based research experiments we presented initial evidence to substantiate these profferings. In times of mushrooming EdTech solutions and platforms there is an urgent need to foreground the essentiality of considerations about design, digital agency and empowerment. More extensive and inter-disciplinary research and framing is needed to generate evidence that can inform educators and policy makers to more meaningfully leverage EdTech for empowering learners and teachers.

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