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The Learning Value of Personalization in Children's Reading Recommendation Systems:
What Can We Learn From Constructionism?

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ABSTRACT

This article critically reviews the personalization logic embedded in reading recommendation systems developed for 2- to 11-year-old children and its (dis)alignment with Papert's constructionist and socio-constructionist theories of learning. It is argued that the current design fails to incorporate the computer culture that Papert envisioned for children's learning. While the personalization design focuses on child-centered design, it restricts the child's contribution to the database, minimises children's agency in shaping it and reinforces individual models of learning. The paper recommends that reading recommendation systems provide opportunities for what Papert described as self-discovery, experimentation, and development of abstract knowledge. Recommendation algorithms need to work in conjunction with diversification mechanisms to challenge and widen children's thinking and diversification should not be conflated with randomization. Practical examples are provided so that the approach described in this article can be used as a foundation for conceptualising and designing children's reading recommendation systems and data-based personalized learning more broadly.

KEYWORDS

Agency, Constructionism, Early Literacy, Open-Ended Design, Papert, Personalisation, Personalized Algorithms, Recommender Systems

INTRODUCTION

In the early 1980s (that is in the era before the appearance of mass-produced personal computers), the mathematician Seymour Papert envisioned that one day, all children would have a personal portable computer that would fit their small hands and enable them to concretize and individualize their own education (Papert, 1980, 1985). A significant part of Papert's vision became reality within his lifetime: in the 2010s, most children growing up in the Western affluent countries (Ofcom, 2014; Common Sense Media, 2016) as well as many African (e.g., Mahamud, Andrews & Rockson, 2015) and Asian countries (e.g., Tyng, Zaman & Ahmad, 2011), have access to tablet computers and smartphones, which are lightweight, portable and easy to manipulate even by two-year-olds. The

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idea of using computers to personalize children's education has become more real with the advent of data-management technologies that use personal profiles to individualize the content children receive (Selwyn, 2016). However, as yet, these devices do not deliver the kind of child-driven discovery and experimentation that Papert had anticipated.

This article provides a close look from Papert's constructionism perspective at a specific aspect of data-based personalised education: the design of children's reading recommendation systems. Papert's constructionism is uniquely placed to inform the design of personalised education systems because it foregrounds digital solutions for public education and because it focuses on children's personal interests in *construct*ing their learning. The key component of constructionism - learning through the creation of artefacts - corresponds to several technology-oriented personalised education programs, including the reading recommendation systems. However, despite this apparent resemblance, there is a discrepancy between the design of personalised education and Papert's ideas. Papert emphasised children's agency in making choices, thinking independently and seeking answers via discovery learning. This paper argues that agency and discovery-learning are sabotaged by the commercial model of current reading recommendation systems. Moreover, the key limitations of Papert's constructionism, namely that it propagates techno-centric and elitist model of learning, are further propagated by the design of these systems. As such, the providers of the personalization technologies have instrumentalised constructionist ideas for commercial purposes and exacerbated its shortcomings. This has significant negative implications not only for children's reading for pleasure but their education more widely.

The argument is built as follows: the first section outlines the core ideas of Papert's constructionism relevant for the context of children's reading for pleasure and the recommendation systems designed to support children's reading in schools. The key benefits of the current systems are described, followed by a set of theoretical issues that frame the discussion of their four limitations: the lack of design for children's 1, cognitive challenge, 2, agency, 3, discovery and 4, child-led learning. A theoretically-informed schematic model of the interaction among the child, reading recommendation database and community of users is presented, followed by a list of recommendations for implementing it in practice.

The examples in the article draw on a conceptual analysis of three popular reading recommendation systems for primary-school-aged children in the UK, which have features available in equivalent systems used in US and Australian schools. When evaluating the design benefits and limitations, the focus is on children aged two to eleven years because this is the age group targeted by the educational programs and addressed by the learning theory addressed in the paper.

DELIMITATIONS AND KEY TERMS

Reading Recommendation Systems

Platforms that broadly fall under the umbrella term of reading recommendation systems include micro library systems, cloud e-book services or adaptive and personalized reading recommendation systems (Wu & Huang, 2016). In this paper, the generic term *reading recommendation systems* is used, which applies to systems that provide recommendations for printed as well as digital children's books, and, in addition to a list of books, can include videos, shows, films, games and apps. Children's reading recommendation systems are offered as subscription services or free online databases. The content can be curated by the system provider and/or the child's teacher or parent/caregiver, depending on the payment model.

Personalization

In the context of children's reading recommendation systems, personalization refers to the process of making the reading experience relevant to an individual user, based on the user's data such as personal characteristics (e.g., readers' gender, reading level, history of engagement). The recommendation algorithm is used to match this information with a database of book titles, and information about

children's authors. Recommendation algorithms can be item-based (item-item) collaborative filtering, and user-based (user-user) collaborative filtering (Ekstrand, Riedl & Konstan, 2011). Both types apply the like-like logic, where a new product carries the characteristics of the previous product, either based on the product's characteristics or the user's characteristics. This article discusses this logic and its associated model theory in relation to the personalisation mechanism. Personalization mechanisms can be used for adpative learning but also for education models that are not algorithm- or data-based but that focus on an individual child (e.g., in child-led play outdoors).

Personalized Education

Reading recommendation systems are an example of technology-mediated personalized education. Personalized education has 'multiple meanings, trajectories and filterings' (Mincu, 2013), with various related terms used in Anglo-American education research and practice, including 'heterogenous teaching solutions', 'differentiated instruction' or 'individualized education'. The 2015 'Innovating Pedagogy' report detailed five personalization themes that had emerged over the previous four years in public education: personal inquiry learning, dynamic assessment, adaptive teaching, analytics of emotions and stealth assessment (Sharples et al., 2015). This paper is focused on the theme of *adaptive teaching* and within this theme, on the specific topic of reading recommendation systems, which are pedagogically under-developed (e.g., Roskos, Brueck & Lenhart, 2017) and argues that the personalization mechanism employed in current recommendation systems is theoretically misguided. Several examples are offered to align the systems' design more closely with constructionist learning principles.

Papert's Constructionism

Papert's theory offers a comprehensive treatise of children's learning with tools by constructing their own content and artefacts. The theory is widely used in technology-oriented studies and pedagogies (Kinshuk, Sampson & Chen, 2013) and when it comes to reading and narratives, it 'is the most integrative and has most explanatory power' (Owen, 2006, p.12). The present argument is built around four key learning principles addressed by Papert's constructionist theory (Papert, 1980, 1993, 1996) and its later derivative, social constructionist theory (Nightingale & Cromby, 1999): 1, cognitive challenge; 2, children's agency; 3, discovery learning; and 4, child-led learning. All four principles have one common feature: the child's active construction of new tools and insights. These ideas have been central to the development of several robotic tools and programming systems for children (e.g., LOGO, Scratch) and interactive stimulation environments (e.g., Turtle, Talos), which support children's analytic and problem-solving skills.

Papert's theory is not without its limitations. Ames and Rosner (2014) rightly point out that proponents of constructionist ideas have often 'enjoyed privileged and quite likely idiosyncratic childhoods' and this privilege was often enabled by the socio-technical infrastructure that they seek to promote in the public education system (ibid, p. 376). It should be also borne in mind that, as with many other educational theories, constructionism is based on philosophical ideas, not robust longitudinal data. Nevertheless, constructionism has inspired some of the largest and most innovative educational technology projects (e.g., One Laptop per Child) and Papert's legacy has become the cornerstone for the first children's programming language (Logo) and the fields of computational literacy and technology-enabled project-based learning (Hoyles & Noss, 2017).

This paper offers a theoretical exploration of the ways in which children can build their own multimedia texts, experiment, verify and falsify their assumptions to *construct* their learning with reading recommendation systems. The proposition is made that the limitations of Papert's constructionism can be addressed by extending some *social* constructionist ideas into the design of children's reading algorithms.

Social Constructionism

Social constructionist theory is, like all social learning theories, concerned with the social, but the constructionist focus emphasises the 'possibility of understandings gained through activity rather than being delivered through instruction' (Jessel, 2001, p.17) and it maintains that construction of knowledge 'occurs not through individual knowledge, but through engagement with others' (Wise & Jacobo, 2010, p.162). Social constructionism contains many, often conflicting, ideas (Cromby & Nightingale, 1999). My argument is positioned within the broader understanding of social constructionism, that foregrounds the importance of a linguistic or discursive focus on meaning-making but also acknowledges the material, embodied and institutional aspect of every human experience (Nightingale & Cromby, 1999). The guiding premise of social constructionism is that 'humans are part of shared collective aims, values and experiences' (Owen, 1995, p. 164). This premise has several antecedents, in particular in the socio-cultural theory developed in Russia in the early 20th century (e.g., Vygotsky, Luria, Bakhtin) and later curated in Scandinavian countries (e.g., Lund, Ludvigsen, Furburg). Supporting children's agency as well as their commitment to community and social structure is a delicate balancing act, with a long history in education. Various other terms have been used to refer to the optimal balance in learning, including merging internalization and generalization processes (Leontiev, 1978), the personal with social (Daniels, 2002) and following the personalized pluralization model (Kucirkova & Littleton, 2017).

Reading for Pleasure

The discussion of reading recommendation systems in this paper centers on reading for pleasure or reading for enjoyment, that is, reading understood as a volitional activity, also known as recreational reading (Ross, McKechnie and Rothbauer, 2006) or free voluntary reading (Krashen, 2004). The focus on reading for pleasure foregrounds systems that support readers' engagement, not reading development (phonics or letter knowledge). Longitudinal research shows the benefits of reading for pleasure measured with ten-year-olds for children's cognitive scores when they turn sixteen (Sullivan & Brown, 2013). Overall, the learning benefits of reading for pleasure fall into four broad categories: health & wellbeing outcomes, intellectual outcomes, personal outcomes and social outcomes and include communication skills, self-esteem and self-awareness, critical thinking and mental health (The Reading Agency, 2017). In the UK, reading for pleasure was introduced in the revised National Curriculum in England in 2014. It places high quality literature at its core and requires that children are taught to 'develop pleasure in reading, motivation to read, vocabulary and understanding by listening to and discussing a wide range of poems, stories and non-fiction at a level beyond that at which they can read independently' (Department for Education, 2014, online). Whether the government's interpretation of reading for pleasure is too narrowly focused on children's independent reading rather than the delight that books can foster, is for another paper. Many argue that for children of pre- and primary-school age, reading for pleasure is not always volitional and agentic (e.g. Bearne & Reedy, 2017). This paper highlights that children's sense of choice and agency in reading for pleasure might be negatively influenced by the design of some currently popular reading recommendation systems.

Key Benefits of Reading Recommendation Systems for Children

The key advantage of children's reading recommendation systems is that they can store large numbers of book titles, categorise them, and in addition, capture users' data, which can be used for refinement of the system, and/or for monitoring the users' activity. Many of these systems employ the same filtering algorithms as the children's entertainment industry (e.g., YouTube Kids Smartfeed). For example, the reading recommendation system Epic!™, which has been adopted in 70% of US primary (elementary) schools in 2016 (Siu, 2016), offers subscription-based access to a large database of children's titles, including interactive and audio books. Once logged into their accounts, users are offered a list of books based on their reading levels and interests, as per their self-selected categories. Children can receive "reading badges" when they reach a given milestone. The system also offers back-end data

("reading log") that is available to parents or teachers who can check the titles accessed by the child and the duration of the child's engagement with specific book titles.

From a psychological perspective, the advantage of reading recommendation systems is that they can avoid *information* overload (Thompson, Goker, Langley, 2004), although in some contexts, if the recommendation is not limited to a manageable number of items, users might experience *choice* overload (Iyengar & Lepper, 2000). From an educational perspective, reading recommendation systems extend class teachers' roles to librarians, curators and monitors (Kucirkova & Cremin, 2017), which, although not unproblematic, has some distinct advantages for the practitioner. For instance, with RM Books™, teachers can select books from a large book database and assign individual titles to individual children; they can regularly update the book lists and easily locate book titles that are linked to the curriculum. Teachers can also monitor children's engagement with the system, which can be used to enrich their professional understanding of children's reading preferences and practices. A particularly beneficial feature is the possibility for bookmarking, which allows children to send each other messages, thus expanding the database to peer-to-peer recommendations (Picton & Clark, 2015).

Examples of Reading Recommendation Systems

To illustrate the design strengths and limitation of current reading recommendation systems, this section considers three examples: The Oxford Owl, MLS Reading Cloud and RM Books. These three systems are widely popular in UK primary schools and have many innovative features, with each system offering children a different reading experience. The exploration of the key features of Oxford Owl, MLS Reading Cloud and RM Books, were constructed without access to their underlying algorithms. This is not unusual in the algorithmic industry, which restricts transparency to preserve its market share. The analysis is theory-driven and conceptual and focuses on the systems' underlying assumptions and key features available to users.

Although the MLS (Reading Cloud) System, RM Books and Oxford Owl Books offer several other services (for example, Oxford Owl offers an eBook Library and storytelling videos), the focus here is only on the recommendation features of the systems (e.g., Oxford BookMatch within Oxford Owl Books, which is a book recommendation tool). All three systems were reviewed as part of an ongoing effort to understand the affordances of personalized education mediated by new technologies in primary schools. The review process involved signing up for the three systems as a user and administrator, and noting down the key design attributes of the systems that are relevant for children's reading for pleasure. Children's and teachers' actual use of the systems are not the focus of this article. Rather, the analysis was deductive (theory-driven) and particular attention was paid to the exchange between the child and database and the relationships among the child, database and the adult teacher, facilitated through the recommendation algorithms.

The illustrative examples are not meant to be a criticism of the three reading systems. The systems address the time and resource limitations of the current reading provision in UK schools and are continuously being improved based on teachers' feedback. The criticism concerns the design and features of the systems, which illustrate an underdeveloped understanding of the pedagogical implications of constructionism for recommender systems and personalised education more widely. The specific aim is to set up a conceptual perspective for explaining the misalignment between Papert's theory and current design of recommender systems. This conceptual perspective is broken down into four theoretical issues.

THEORETICAL ISSUES

Cognitive Challenge

Classic constructionism is focused on self-discovery learning but a radical constructionist theory, which was a direct continuation of Piaget's *constructivism*, emphasizes the role of cognitive conflict

in effective knowledge construction. This theoretical supposition has been confirmed by a body of literature from mathematics education research that has shown that harder versions of the same task yield better results (Ejersbo & Leon, 2014; Brown, Roediger & McDaniel, 2014). For instance, Kelly & Tangney's (2006) work on the EDUCE adaptive educational system showed that contrary to developers' expectations, students learnt most in the *least* preferred condition. Papert maintained that cognitive challenges were the essence of the children's self-discovery learning approach, in which they construct their own contents by directly manipulating tools. He emphasised the need to offer children 'more challenging opportunities than was conceivable in the pre-digital era' (Papert, 1999, n.d.). In the constructionism curriculum, children learn through play, design and programming tools. It is learning through making, supported with tools, which can be, but don't have to be, digital technologies. When children make their own "stuff", they test and challenge their existing assumptions and they encounter and solve cognitive challenges.

The current reading recommendation systems seem to be built on the logic of a search engine that 'understands exactly what you mean and gives you back exactly what you want', as Larry Page, Google's former CEO, has stated. The logic of the system is to gather as much data as possible about the user and match it with the database to provide a personalized recommendation. Accordingly, MLS, RM Books and Oxford Owl are not designed to make the process challenging. Such a design logic goes against the concept of 'hard fun' (see Papert, 2002), which emphasises the importance of extending learning to unexpected dimensions. This aspect was one of Papert's (2002) key criticisms of the public school system: 'My whole career in education has been devoted to finding kinds of work that will harness the passion of the learner to the hard work needed to master difficult material and acquire habits of self-discipline.' Papert's learning theory calls for actively solving, not automatically overcoming, problems. The first limitation of children's reading recommendation systems is therefore linked to the designers' conceptualization of children's learning and the misguided design idea that children would be motivated to read if the system predetermines the choices for them and minimises any challenges on the way.

Children's Agency

When Papert developed the LOGO computer language, he aimed to give children a means of programing computers to do the things that children wanted them to do. Papert (1995) explicitly encouraged children to take lead in their own learning. He followed in Piaget's footsteps to emphasise children's active involvement in constructing their knowledge and he saw the creative, open-ended potential of computers as central to children's creation and composition. While the analogue world has resource limitations, the virtual world offers all children the possibility to make their own avatars, castles and robots. Parents and teachers can support 'children as they build their own intellectual structures with materials drawn from the surrounding culture' (Papert, 1980, p.32).

Yet, the current reading recommendation systems offer few agentic opportunities for children - a problem noted also in adult-oriented recommender systems (Knijnenburg, Sivakumar & Wilkinson, 2016). Adult recommendation systems have been criticised for guessing the user's intent from poorly designed algorithms which minimally integrate actions, attributes and contexts (Margalit, 2016) and similar criticisms apply to the systems developed for young children. This is particularly important in the context of reading for pleasure in English schools, where children's choices are often mediated by their teachers. With the reading recommendation systems, children's reading choices become mediated by the assumptions of publishers/developers, but not the child's own volition. As such, two groups of adults mediate children's reading choices, which might be beneficial in some contexts but is problematic in relation to reading for pleasure. A reading recommendation system that collects data on a child's engagement with books, and generates graph data and predictions, can easily turn into a monitoring and surveillance tool. Children's choices become the subject of comparison and evaluation, giving rise to hierarchies of preference and books' status. When given the choice, children select books that are different from those they get recommended at school, with

a significant discrepancy between children's popular and school reading culture (see Coles & Hall, 2002). Systematically evaluating children's reading choices thus risks widening, not reducing, the school/out-of-school reading divide. To avoid this, reading recommendation systems need to provide space for independent and/or mediated input from the child.

Giving children more agency foregrounds the social role of knowledge and the role of culture and society in generating a cognitive conflict and accomplishing its solution (Hoffman, 1990). Content offered to children should be regularly reviewed based on children's preferences and their family and teachers' recommendations, not just the book provider and the publishing market. Although expert input is necessary to keep the reading community safe from inappropriate content, Papert would argue that this should not preclude the database from accommodating new authentic content generated by the child. Children can write their own stories, provide book reviews or comment on others' texts. They can compose/create their own multimedia stories. Existing digital books in the database can inspire children's contributions and become the tools with which children test hypotheses, develop ideas and communicate their understanding to others. It follows that the second limitation of the current design of reading recommendation systems is that it restricts the child's contribution to the database and minimises children's agency in shaping it.

Discovery Learning

Similar to other personalized systems, reading recommendation systems are based on the principle of similarity, where a recommendation is similar to the child's reading history and corresponds to children's preferences. For example, if a child likes action stories, the system will recommend action stories and content related to action stories. The systems might also recommend titles that are similar to what other users, who liked action stories, had read or accessed. The underlying assumption is adopted from business models, which use content liked or used in the past for future purchase recommendations (Lin, 2014). Programmatic data are also widely used in medicine where pattern prediction can assist in matching users' data with a given database. However, following this logic in reading recommendation systems runs the risk of reproducing the limitations of learning analytics (see Perrotta & Williamson, 2016), which have created a fixed database that supports a linear progression as opposed to a multi-dimensional and dynamic web of knowledge-building. While efforts are underway to produce more robust personalization learning platforms for older students (Lu, 2004; Benhamdi, Babouri & Chiky, 2016), the filtering mechanisms for young children's reading for pleasure are still very much in their infancy. Papert emphasized the need for children to discover and explore new concepts through hands-on, opportunistic and idiosyncratic learning (Squires & Preece, 1999). He argued that the digital medium can facilitate serendipitous learning, while 'the printed page cannot capture either the product or the process' (p. 93). Child-led discovery learning with computers is important for the development of their abstract thinking skills. In the case of kindergarten-aged children, discovery-learning develops best with adult mediation (Klein, Nir-Gal & Darom, 2000). This type of learning is not enabled with reading recommendations systems: instead of facilitating discovery learning and mediation, the systems are designed to track, program and systematically evaluate children's reading for pleasure. Such an ongoing evaluation and surveillance of children's reading is not about exploration but about following a pre-determined path. And yet, from a constructionism perspective, there is no single answer that is "correct"; learning happens in a spiral-like fashion: children construct ideas that lead to a construction of things, which leads to further construction of ideas, refinement of things. The third limitation of the reading recommendation systems is therefore the inflexible conceptualisation of learning that allows no space for children's growth through explorative making.

Child-Led Learning

A key tension in Papert's constructionism is the emphasis on children's agency in their learning. On one hand, its unequivocal advocacy for children's agency is its biggest strength but on the other hand, it is an expression of Papert's exceptional childhood that was privileged in terms of gender,

culture and socio-economic status. While for Papert self-driven learning has undoubtedly contributed to a remarkable career, it cannot be assumed that all children will have the opportunities that Papert enjoyed in his specific socio-cultural milieu (Ames & Rosner, 2014). The reality is that schools need to cater for all children and worldwide, children face multidimensional poverty-related issues, with unequal access to learning opportunities (Unicef, 2017). The reading recommendation systems do not address ingrained inequalities. Instead, the systems adapt their offers based on the child's data, which incorporate children's reading levels and history of engagement. Paradoxically, as it is the case with several current instantiations of personalised education, such an approach may unintentionally reproduce educational inequalities (see Kucirkova, 2017). If personalization is misapplied, it can homogenise disadvantage or even entrap children in a role they have not created for themselves. In the case of reading for pleasure, it can misrepresent the breath and scope of children's reading.

Another limitation is that the systems use algorithms suitable for adult users. These are designed to offer personalized content, by automatically tracking users' reading and/or purchasing history and based on these data, to select content tagged with corresponding attributes. The aim of such design is to connect people around a shared interest or to present readers with information that matches their interests. Adult-based reading recommendation systems do not face the content limitations inherent in children's reading platforms because they crowdsource recommendations and provide a social space of knowledge sharing. For example, ReadGeek or LibraryThing connect people of shared reading interests and sustain an online community, which generates a potentially unlimited, iteratively refined, database. For instance, in November 2016, the LibraryThing™ had 2,123,453 members and 111,304,889 catalogued books. The site charges a membership fee, and users are expected to actively contribute by writing their own reviews, uploading photos of book covers, reporting spam and inaccurate data, organising new series and setting up new communities or off-site meetings. However, applying adult models to children's reading platforms gives rise to several limitations: first, adult behaviour doesn't automatically translate to children (Rourke, 1983) and designers need to account for children's cognitive and emotional maturity. Azpiazu, Dragovic and Pera (2016) voiced similar points of view in relation to the design of search engines and their use by children. Second, researchers have pointed out that there is an acute need to improve the privacy and security of using children's personal data and obtaining children's informed consent to archive and share their data in recommendation systems designed for adults (Ng, Holtby, Ma, Aucinas & Tasker, 2017). Third, reading recommendation systems for adults are designed to harness the power of communities, while the systems for children reduce communities to one or two teachers. Children can like or dislike individual reading titles, while their teachers (positioned as system administrators) can check children's activity and assign new content to the database. In sum, the fourth limitation of the systems is that they reinforce individual rather than collectivist models of learning.

Papert used the metaphor of Brazilian samba schools to convey his vision of future schools. He envisioned them as communities of diverse learners from all walks of life, across all ages, who come together to learn *with* each other and *from* each other through direct participation in choreographing and dancing. This idea has been successfully extended to the Scratch programming language and its online communities across the world, led by Professor Mitch Resnick and colleagues. The participatory element of community-based learning and making needs to be extended to the reading world. Reading is a social act and requires the input from a wider community. Children and their teachers, caregivers and peers should be provided with opportunities to interact around their favourite stories and mutually mentor and instruct each other. Stories are a primary tool for connecting communities of diverse ages and backgrounds and the virtual world widens the diversity of collaborative co-construction of stories and learning from each other.

Schematic Model of Children's Reading Recommendation Systems

In summary, in order to increase the educational value of personalization algorithms in children's reading recommendation systems, designers need to:

- Provide space for a cognitive conflict and challenge children's thinking;
- Provide more opportunities for children's agency and content generation;
- Develop databases that are open-ended and not based on linear and definite models of learning;
- Allow for the inclusion of community-generated content from peers and parents/ caregivers/educators.

In future models, content crowdsourced from communities should be *personalized* for individual children and through the system's sharing mechanisms, *diversified* for other children accessing the database. The combination of algorithm-driven personalization and diversification would unify the child, database and community elements in one cycle. These points can be rationalised in a simple schematic ABC model where the relationship between the three key variables (Child, Database and Community) correspond to three ovals (A, B and C). As shown in the Figure, (A) represents the child, or an individual's activity and user-generated data. The data generated by the child are augmented and multiplied by the knowledge contained in the reading database (B). The database is iteratively developed by the experts/professionals/ community members (C).

The size of each oval will be proportional to the emphasis placed by different stakeholders and industries on the individual building blocks. In a socio-culturally oriented model for example, the size of the third oval (community) will be bigger than the size of the first oval (representing the child's own knowledge and individual activity).

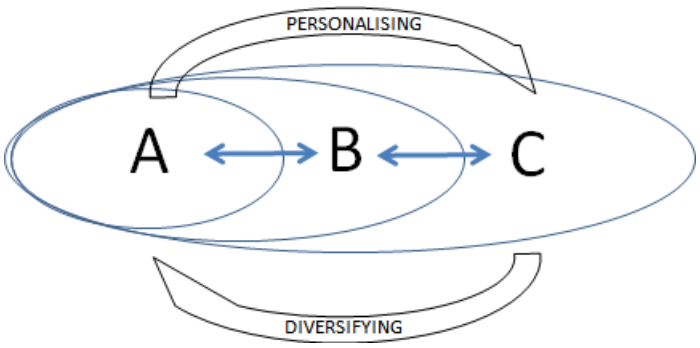
To concretise these theoretical suggestions, the next section details the model's individual constituent parts and working mechanisms with some arbitrarily selected examples adopted from current learning platforms and research projects. The purpose of these examples is to illustrate that the suggested theoretical potentialities can be connected to actual design, not to restrict the design to a specific example. As in the previous sections, reading recommendation systems are used as a case in point.

PRACTICAL RECOMMENDATIONS

Cognitive Challenge: Diversification Mechanism

The first practical recommendation relates to the theoretical suggestion that personalization algorithms need to work in conjunction with diversification mechanisms to challenge and widen children's thinking. Adults' recommendation engines often conflate diversification with serendipity or randomization. For example, the Poetry Archive website offers the so-called "Lucky dip, Delight me" feature, which generates a random recommendation of poetry recordings. This is different from the diversification mechanism, which is an algorithm that is designed to provide recommendations that

Figure 1. Schematic representation of the personalization and diversification mechanisms in recommendation models



are purposefully dissimilar from what users accessed before. Ziegler, McNee, Konstan, and Lausen (2005) suggested, and empirically tested, a topic diversification approach in adult-based reading recommendation systems. In this approach, users received recommended items that were dissimilar from the items the users had liked or received before. Ziegler, McNee, Konstan, and Lausen (2005) used a topic diversification approach and reported greater user satisfaction because users received recommendations that covered a broader spectrum of their interests than with a personalized approach.

Diversification recommendations are not random suggestions: they are programmed recommendations based on a child's data but dissimilar from the child's own preferences. If, in addition to personalized recommendations, the recommendation systems provided recommendations that do *not* match children's preferences, children would need to sift through book titles and ask questions such as: Is the author someone I know? Is the story of interest to me? Such a selection process would, according to social constructionism, support the development of new preferences, acquisition of new information and active search for new answers.

Children's Agency: Child-Led Design

The notion of children's agency directs the lens on children's active participation in the design of educational resources developed for them. Cooper (2002) involved children in the design process of a book-search platform and showed that to children aged between four and nine years, categories pre-selected by adults did not make sense. While a typical book-search category selected by adults would be a fiction versus non-fiction distinction, young children preferred categories based on their favourite story characters (e.g., dinosaurs, dragons, and princesses). The International Children's Digital Library (see Druin, 1999), which currently offers free access to children's literature in more than 40 languages, therefore actively solicits children's input for its site design. Recognising and valuing children's reading choices does not mean emulating adult design of reading spaces such as Goodreads and asking children to 'like' or 'review' a book. Rather, it calls for more participatory design of the reading systems, where children are positioned as co-researchers, who test and suggest new solutions before they are finalised. Participatory design with children is an approach to reading and education systems design that draws on children's agency throughout the whole development process, including the final product.

Discovery Learning: Open-Ended Design

Giving children more agency does not mean offering them fully personalized solutions. Personal preferences are idiosyncratic, incomplete (Loomes, 1999), irrational (Harsanyi, 1977) and context-dependent (Grether & Plott, 1979), and therefore difficult to predict with algorithms. While in personalized medicine, incompatibility or poor matching could result in rejection of a transplant or compromise a healing process, there is no need for full personalization in education. Rather, reading recommendation systems should provide opportunities for what Papert described as self-discovery, experimentation and development of abstract knowledge.

These opportunities are best provided through platform-agnostic open-ended systems that allow for flexible and accessible content use and upload by users of varied skills. Some of these features are embedded in LearningField, an initiative of Copyright Agency in Australia, currently offered to 7–12 –year old students as a subscription service of e-books. The site allows teachers and students to select specific chapters or book passages, comment on these and share them among each other, in any online workspace, including forums, Wikis, blogs or a school's existing learning management systems. For younger children, self-discovery and experimentation can be encouraged through open-ended story-making apps and software programs. There are several story-making applications (e.g., Our Story) that are widely popular among young children and that enable young children to create their own multimedia stories and share them with others. Making-centered reading systems are more commensurate with the values of reading for pleasure research that aims to ensure that children's reading experiences in schools are not reduced to phonics and letter-recognition sessions but that

they hold the space for nurturing pleasure from reading and developing long-life readers (Cremin, Mottram, Collins, Powell & Safford, 2014).

Child-Led Learning: Community Engagement

Community engagement is possible on child-oriented reading platforms, as long as it is follows best practice design for children, such as data protection and privacy by design. As for some examples that could inspire future models, the Storyweaver™ platform developed by Pratham Books (https://storyweaver.org.in/), supports the creation and translation of original stories crowdsourced from the community members. Several discussion-oriented features support users' interaction on the platform and encourage their contribution: users can write reviews, ask each other questions and comment on individual titles. All stories are free to view and download. The Storyweaver's open nature of feedback discussions and the users' direct expression of favourite titles, could be emulated for other reading recommendation systems. For children with more advanced literacy levels, reading recommendation systems could be connected to children's writing platforms that position children as story authors, editors and distributors. For example, the Popup Hub (https://pop-up.org.uk/project/an-online-space-to-explore-create-share-stories/) offers several options for children to write their own stories, book reviews and impressions on the books they have read. Teachers, librarians and the children themselves could help connect these spaces to the information fed to the personalization algorithms, corresponding to the suggested ABC model for future design of reading recommendation systems.

CONCLUSION

The technology necessary for the creation of rich reading recommendation systems is widely available, and literally in children's hands. It is time to reflect and rethink how we could benefit from the computer culture that Papert envisioned for children's learning. This paper provides some thinking tools and examples for aligning the personalization algorithms in children's reading recommendation systems with a specific learning theory. The argument focused on children's reading recommendation systems as an example of digital personalization in early childhood. This specific focus is useful given the rising popularity and influence of personalization algorithms in children's mobile learning (Garcia-Cabot, de-Marcos & Garcia-Lopez, 2015) and marketing practices (see e.g., Hill, 2015). The ideas discussed in this paper need to be contextualized in the wider debate around algorithmic/datafied personalized education, which is driven by technological and commercial - rather than pedagogical or theoretical - innovations (Saltman, 2016, Wiliamson, 2016).

Implications for Personalised Education

Selwyn (2016) and other leading educational scholars (e.g., Williamson, 2016) have argued that current personalized education models have adopted a business-driven mass customisation model of personalization. In these models, personalized education is conceptualised as an approach to learning where each child is presented with pre-selected content in a different sequence or quantity, or to use the business term, in a different value bundle. The possibility to pick and choose is supposed to motivate and engage children and build on their preferences and needs. Given that content customisation, search and curation are faster, more comprehensive and more seamless in a digital format, this model of personalized education is delivered to schools exclusively on digital platforms.

However, such models 'position education within a reductive set of economic rationalities that emphasize human capital development, the expansion of data-driven instruction and decision-making, and a narrow conception of learning as the acquisition of discrete skills and behavior modification detached from broader social contexts and culturally relevant forms of knowledge and inquiry' (Roberts-Mahoney, Means & Garrison, 2016, p.1). Selwyn (2016) further argues that current personalized education models marginalize the role of teachers' expertise and go against a community-based model of education. In individual-centred educational models some students thrive and some

simply fail and education becomes dominated by a small group of technology giants (e.g. Amazon, Apple, Facebook and Alphabet) rather than educational professionals. Such a conceptualisation of personalised education has been described as a 'marketing strategy for an ed-tech product' (Molnar, 2016, online) rather than a pedagogy-based model for 21st century education.

The current reading recommendation systems illustrate some of these broader concerns in that they assume, rather than actively support, children' agency. They also minimise the mediating role of adults and peers in children's learning and apply a commercially-driven (like-like) logic to personalizing children's learning. Before developing specific mathematical formula or implementing reading recommendation systems in classrooms and offering them to parents commercially, it is essential to reflect on our assumptions about children and their learning. This paper outlined how the current reading recommendation systems could offer more opportunities for children's agency and access to diverse and crowd-sourced content. It highlighted the design principles that could constructively engage children in non-linear, abstract thinking. If reading recommendation systems are to provide children with lasting and holistic educational benefits, their design needs to be informed by a personalization mechanism that is conceptualized through an interdisciplinary and open dialogue between researchers, designers and educational professionals. The theoretical work presented in this paper is a significant step towards this goal.

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