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Education 3.0 and beyond: A learner-led experience of Education

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Abstract: The last decade has seen technology entering the education space in multiple ways – through digitised learning content, adaptive online tests, pre-recorded or real-time videos of teachers, social networking, MOOCs, etc all that have been classified as Education 1.0, 2.0 and 3.0. The predominant reference of these terms has been for higher education (college level and beyond). It assumes that the student is a mature and motivated adult who is able to take in discrete pieces of information and assimiliate it coherently to learn. This paper explores how Education 3.0 concepts are implemented in the realm of elementary education with a focus towards increasing students' learning outcomes. This paper combines our research in heutagogy by drawing on data from an intelligent tutoring system called Mindspark that has been used by over 80,000 students in 150 private schools over the past five years as well as in 5 after-school remedial centres in urban slums of Delhi. There is a shift in educational processes - characterized by the transformation from a teacher-led delivery model to a student-led learning experience. In this Education 3.0 model, the learner is no longer a passive recipient but rather becomes an active player in defining their learning environment, the teacher-learner interaction, affective factors of learning, evaluation, interventions and finally achievement – all towards achieving higher outcomes on students' learning.

Keywords: Education 2.0, Education 3.0, intelligent tutoring system, elementary schooling, technology in education

1. Education 3.0 – Newer trends in elementary education

Education technology has seen varied changes resonating users' social experience and interaction with the Web. In line with the various versions of the Web there is an evolution of educational processes as Education 1.0, Education 2.0, Education 3.0 and finally Education 4.0. This evolution draws in from the ideas like progressivism and social constructivism. The ideas of progressivism in education (as purported by thinkers like John Dewey) talk about how "learning by doing" allows for a more active environment for learning where the learner is able to develop problem-solving and decision-making skills. Social constructivism recognises that culture plays a large role in cognitive processes and learning (Vygotsky) and student dialogue and discussion and collaborative learning processes are emphasised. Technology has been a catalyst for these ideas in education, wherein content can be made more meaningful and interactive for the learner and executed even in operational constraints like low availability (in quantum or quality) of teachers and teaching resources.

Education 3.0 is a shift in user-driven motivation, teacher facilitation and in pedagogic styles. According to Jackie Gerstein, use patterns of students should drive the type of mobile learning activities so that the transfer outside the learning setting can occur. The role of the educator in this new environment transforms from being gatekeepers of knowledge to becoming model learners who can demonstrate self-directed learning (Gerstein). While Education 3.0 and 4.0 suggests ubiquitous learning is possible with freely available resources and user-generated content and processes, one needs to interrogate how effective this process is for elementary school students. Can such large amounts of learning content be moderated intelligently by students? Can a 5th grader be expected to read large volumes of data on historic wars and discern reliable sources from non-reliable sources? Can a 2nd grader have the requisite knowledge to decide what she/he needs to learn after finishing addition of fractions? To make it effective, Education 3.0 for elementary education will need to adapt to some of the things that are taken for granted in adult education in Education 3.0.

In this light, we will look at how the learning process in elementary education is aligned to the principles of Education 3.0 in three aspects. The first aspect of analysis will be the learning environment which will describe the online interface with its various features for students to engage with their teaching learning content, understanding their own learning achievement and progress, communicate their emotional states on specific content, receive rewards based on achievement for motivation to continue further and many others. The second aspect studies the role of the teacher in this new learning environment. The third aspect is the dynamic nature of the learning content that is served in real time driven by user response. This section will describe the logic of learning content sequencing through data driven misconception identification and remediation, recognition of prior learning, variable learning path and students' learning while being in flow. Table 1 below is a brief understanding of the shifts in the various generations of education as explained by John Moravec and Arthur M. Harkins (Moravec, 2008 and Harkins 2008) and the next section will describe how the above concepts of Education 3.0 have been implemented utilizing Mindspark.

Table 1: The various generations of educational technology

	"Download" Education 1.0	**"Open Access" Education 2.0**	**"Knowledge Producing" Education 3.0**	**"Innovation Producing" Education 4.0**
Meaning is..	Dictated	Socially constructed, with aid of Internet access	Socially constructed and contextually reinvented knowledge	Build through selective individual and team-driven embodiments in practice
Technology is ...	Confiscated at the classroom door	Cautiously adopted open access	Everywhere	Always changing with learners as a source of innovation production
Teaching is done...	Teacher to student	Teacher to student and student to student	Teacher to student, student to student, student to teacher, people-technology-people	Amplified by positive innovation feedback loops; ubiquitously and creatively 24/7 in all phases of living, learning and working
Schools are located...	In a building (brick)	In a building or online but increasingly on the Web	Everywhere in the "creative society"	In the globally networked human body, a continuously evolving instrument innovatively supplementing and replacing classrooms
Parents view schools as...	Daycare	Daycare with a laboratory	Places for students to create knowledge	Schools are viewed as one of many innovation venues
Teachers are...	Licensed professionals	Licensed professionals who team with students and parents	Everybody, everywhere backed by wireless devices for knowledge production	Everybody, everywhere is an innovation production source backed up intuitive software "partners" and human collaborators.

2. Mindspark – Intelligent Tutoring System

Educational Initiatives, India developed an intelligent tutoring system (ITS) called Mindspark in 2008 which is used for teaching Mathematics and Language to elementary school students. In 2014, the Mathematics program is used by over 80,000 children in private and government schools and the

Language program is used by 5,000 children in government schools and after school remedial centers. An Intelligent Tutoring System (ITS) is a computer based tutoring program that provides personalized learning content to students based on factors like student performance and prior knowledge (Corbett, Koedinger and Anderson, 1997). The sequencing of learning content is done in a manner to avoid cognitive mismatch such as cognitive overload for low performers and boredom for high performers (Brusilovsky and Milln, 2007) to ensure that child is engaged and is performing at the optimum level (Csikszentmihalyi, 1998) . In Mindspark, the questions are 'finely-graded', meaning that there are a very large number of questions of gradually increasing levels of difficulty. In a way, Mindspark adapts to the needs of every individual student. Questions are specially designed to test understanding and to help students clear their misconceptions. When a student answers a question or combination of questions incorrectly, the intelligent system diagnoses the child's misconceptions / weak areas. The child may be further provided with a simple or detailed explanation, or be redirected to questions that strengthen the basic understanding. These decisions are taken by an adaptive logic which is expected to get better and better with increased student usage (Rajendran and Muralidharan, 2013). There is very little emphasis on instruction due to the belief that students learn when they have to think – either by answering a question, or by doing an activity on the computer (Prince, 2004).

An independent third party evaluation of Mindspark shows an effect size of 0.40 against a comparison group with usage as low as 1 hour per week (50 hrs per year). This study finds a favorable outcome despite the teacher effects and school effects that may occur. This study was done across more than 4,400 students from 18 different schools that used Mindspark comparing with more than 15,000 students across 150 schools that did not (IDInsight, 2014).

3. Technology in Education 3.0 is…

3.1 Providing student intelligent and limited choice

The Mindspark portal hosts the interface for every student, where the content is available to students depending on their learning levels. This becomes a dynamic classroom for every child where they have a certain choice of topics to choose from based on extent of completion, performance on the pre-requisite topics, teacher intervention and the adaptive algorithm. Intentionally the entire content is not left open at the discretion of the student. These are shown on the left side in Figure 1. This session is bookmarked to the place where the student left the previous session and allows the student to continue from the same place.

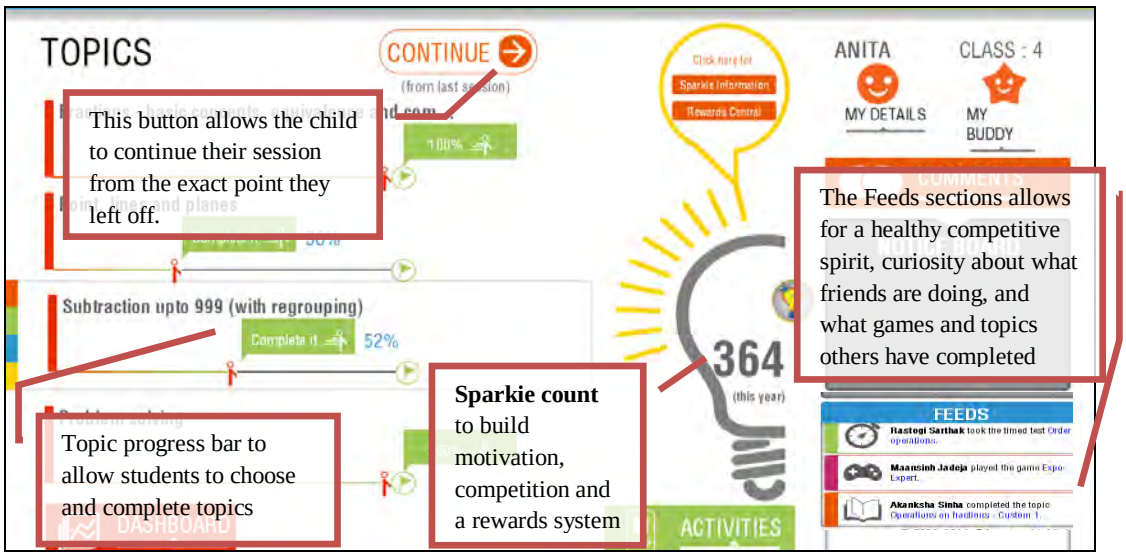

Figure 1. Dashboard for Mindspark

3.2. Providing the encouragement and incentives customized to each child's needs

While technology has allowed for systematic archiving of content and assessing student performance, it is often felt that affective factors like boredom, motivation, and sensing emotional states of the learner are outside the purview of technology. Although intrinsic motivation to learn often helps students approach technology based learning tools, at times, they need a little push to persist at it, with minimal human interaction. Skinner's work on rewards and reinforcements (Skinner, 1938) has been applied extensively by teachers and educationists in working with student behaviour and motivation. These are replicated by Mindspark through creating extrinsic rewards called "Sparkies" to promote positive learning habits like grit and persistence required to help students learn and progress from the mistakes they might make; and to cope with the increasing difficulty levels of questions. Sparkies are shown by the number 364 in Figure 1 above.

3.3. Capturing students' emotions

In addition to this, the tutoring system tries to gauge the student's emotional state through an Emote Toolbar shown on the right side of Figure 2 (to share feedback on moods and emotions related to content). This also provides data to analyze questions that have been repeatedly marked by students as "Boring", "Exciting" or "Confusing". While this data is currently used to review and modify the learning content and its sequencing for greater student engagement, research on affective states of learners indicates that there in future there is a possibility to predict frustration and also address it in real-time through the program's learning environment (Rajendran, Iyer, Murthy, Wilson and Sheard, 2013).

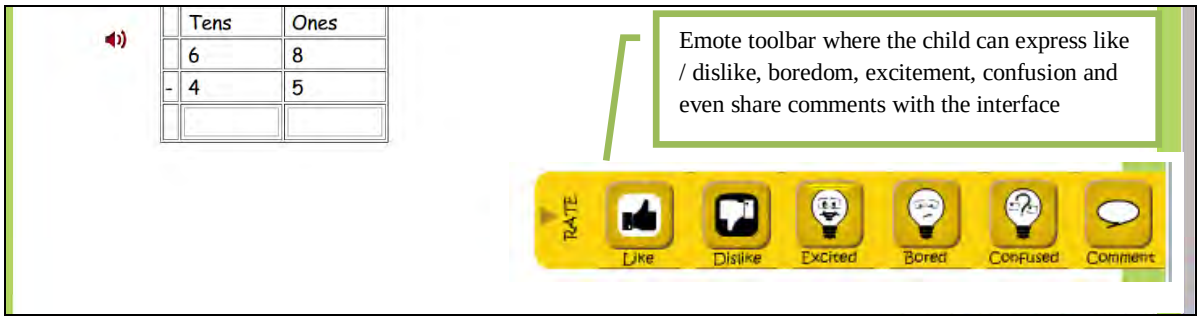

Figure 2. Emote toolbar to capture levels of interest, boredom, frustration etc.

3.4. Providing students transparency and visibility into their learning

Mindspark helps children keep track of their goals through a tabulated Cluster chart shown in Figure 3 to track their levels of completion as well as success. Mindspark believes that keeping students well-informed about their learning process will help them be more aware of themselves as learners and therefore, understanding the value of what is being presented, do better. This is why students are also given prompts telling them when they have finished a learning unit successfully and when they are being made to repeat a learning unit or attempt more basic learning units, as is the case when they get a number of questions incorrect.

Add Sub up to 999 - Pre Math module	Arranging and adding any whole numbers	Knowing facts for division by single digit number	Dividing a 2- digit number by 1 digit number	Division - Pre math module	Problems based on multiplication and division
Dividing a 2-digit number by 1 digit number standard	Dividing a number by multiples of 10	Multiplying two 2-digit numbers vertically	Multiplying a 3-digit number by 1, 2 digit number	Problems involving more than one operation	Estimating products
Introduction to basic fractions (half and quarter)	Introduction to fractions	Basic understanding of half and quarter	Naming fractions and understanding fraction notation	Understanding fractions as part of a collection	Identifying right angles
Save TOTO game	Measurement of length -interactive	Using standard units of length (m and cm)	Using standard units of length (km and m)	Concept and computation of perimeter	Informal understanding of area

Figure 3. Cluster charts that show extent of completion and accuracy

3.5. Providing encouragement to those who have done well, and support to those who need it

Encouragement is provided to students when they achieve certain milestones (Figure 4: "Great going, Anita") so that their energy and enthusiasm is renewed for the next topic. In addition to this, the reward system (Figure 5) applauds diverse qualities like being consistent and perseverant, academic achievement etc. There is a monthly competition among students to become champions in their classroom based on the speed, accuracy, complexity of questions as well as reading explanations to encourage higher usage.

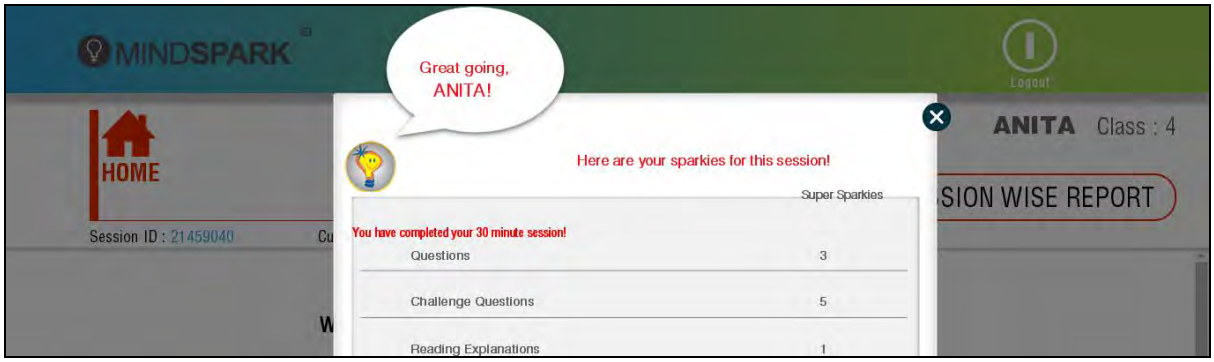

Figure 4. The student interface showing various interactive elements like Sparkies (rewards), encouragement statements, and emotional sensors

Figure 5. Reward system at the classroom level

3.6. Personalization based on the student, time of year, geographic location, festivals, etc

Mindspark allows for personalization of celebrations like an animated "Happy Birthday" greeting card on the student's birthday that opens up on the first login of that day. It also allows for localization of content through interface themes related to upcoming festivals as shown below on the left hand side of the login page during an Indian festival (Figure 6). This space is also used to profile accomplished mathematicians thereby providing the inspiration to become one.

Figure 6. Mindspark login page showing public announcements for Sparkie Champs and greetings

3.7. Providing specific step by step intelligent responses

Technology in Education 3.0 is used more for ensuring that children are learning by providing intelligent responses instead of simply marking students right or wrong (which can be discouraging). Here feedback provided is customized to the type of error that a student is making as shown in an example leading to solving a linear equation with popular mistakes that students make.

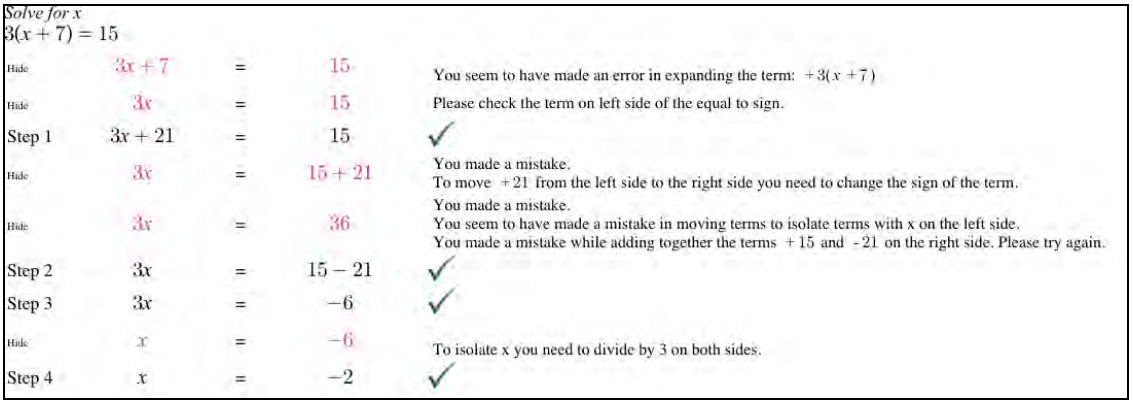

Figure 7. Intelligent responses to errors made by students while solving linear equations

4. In Education 3.0 Teaching is done…

4.1 By reading accurate and instantaneously generated reports of classrooms

Teachers are able to gauge performance, students' needing attention, level of comprehension through system generated reports to aid in teaching.

Students	Progress	Total Q's ↓	% Correct	Total Attempts	Learning units not cleared	Trail
Aswin Benedict	35.9%	273	48.7	1	Representing numbers up to 9999 using base ten blocks and abacus	Trail
Pradeep K	↓ 33.6%	234	42.3	1		Trail
Susmitha V	60.3%	188	46.8	1		Trail
Santhosh M	↓R 100%	183	80.3	2		Trail

Figure 8. Class level reports showing topic progress across various students

4.2 Using real time data for effective monitoring

In this model, the teacher is provided by system driven prompts to help facilitate their teaching in a Mindspark class. Through the dashboard (shown below in Figure 9), a teacher is able to ascertain the child's comfort with the learning content and provide support to students struggling with concepts. This is done by a combination of the pace at which questions are done (system flags if some student is really slow), the accuracy with which it is done and shows relevant parameters (such as class grade level vs. actual level, etc)

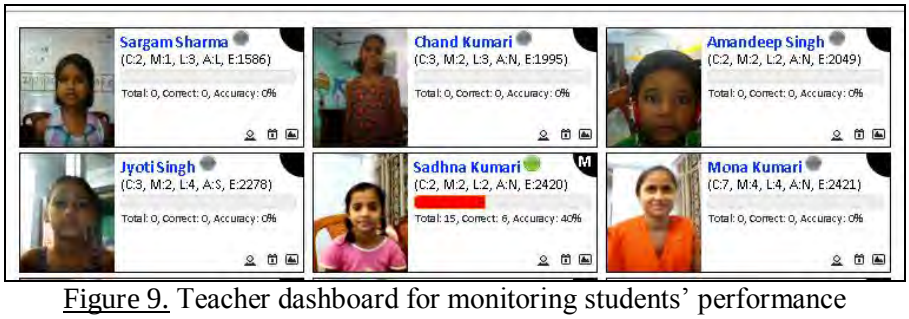

Figure 9. Teacher dashboard for monitoring students' performance

4.3 Better communication with parents

Through system generated reports, the teacher is able to accurately gauge the learning levels of each child and communicate the learning gains and the challenges with parents and to set goals for their students for subsequent months. Also through the teacher interface, the teacher is directly able to email students' parents who can also monitor the progress via the parent portal.

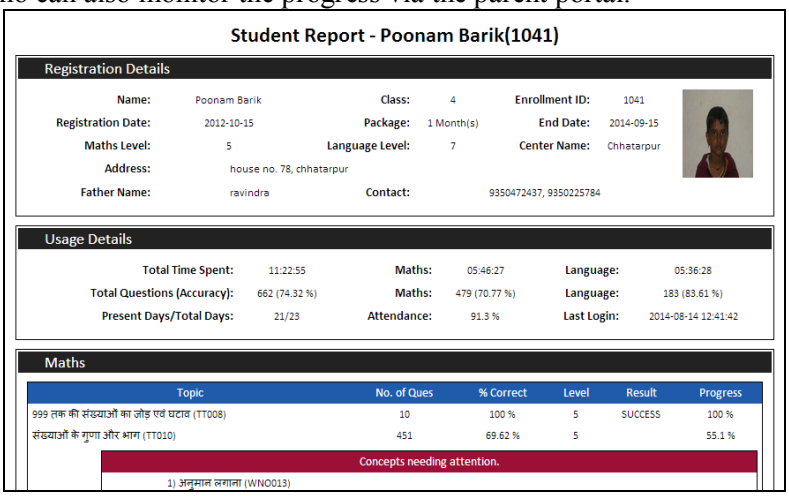

Figure 10. Monthly report on student usage and accuracy shared with parents

4.4 Data driven instruction

Through data on student performance across levels, topics and questions, teachers are able to identify learning misconceptions and plan their offline instruction to help kids through these. For eg. in image below the question shows the "Most common wrong answer" that children have picked as a result of a popular misconception as well as kids who never got the concept right even after being given multiple times. This allows the human teacher to intervene and teach the particular concept. Also the Common Wrong Answer report can be downloaded as a worksheet – printed copies of which can be given to children for practice.

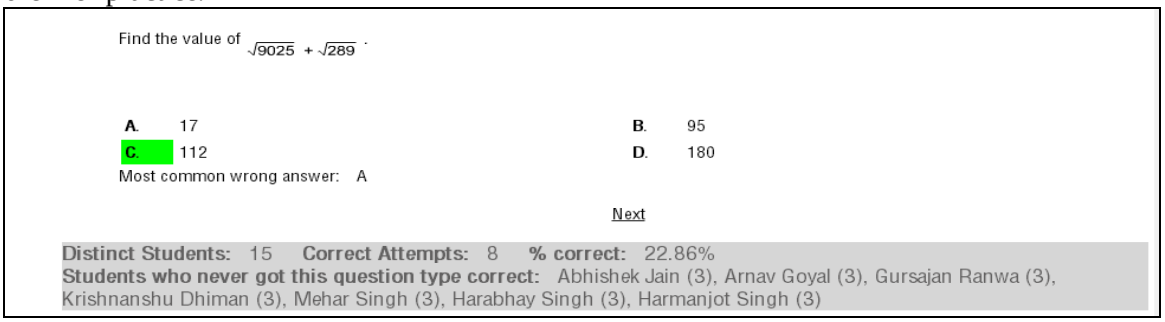

Figure 11. Common Wrong Answer reports

4.5 Teacher-led customization of learning content

While Mindspark provides the learning path for every child, flexibility and autonomy is given to the teachers to allow students to focus on a particular concept determined important by teacher or school. This can be done at the individual student level or at the entire class level.

Figure 12. Topic customization by teacher – for individual level or class level

5. In education 3.0 the learning content is…

5.1 Integration of online content with school curriculum

Teachers using this program integrate Mindspark into their curriculum plan whereby they 'activate' topics for students based on content taught in class and use the performance results of students to identify degree of comprehension, common misconceptions, and low performing students. It thus aims to use not just the interactivity of the computer, but its intelligence; and to mimic the diagnostic capabilities of a good teacher. In addition it also serves as a powerful teaching tool in these cases allowing teachers exposure to good learning materials.

Figure 13. Integration of Mindspark in the school curricula

5.2 Informed through data on student performance and misconceptions

Similar to the discussion on Common Wrong Answer reports, the program captures data on student performance across topics to identify misconceptions. The learning content recognises these misconceptions and attempt to address these through its content flow. Examples of student misconceptions diagnosed and addressed by Mindspark are

- 20 = 5x4 is considered wrong by many students (most students think that 5x4=20 is the only correct notation)
- Confusion between terms like k + 3, 3k, k^3, etc

5.3 Appropriate to the learner's abilities and learning levels

The learner's journey begins with a baseline diagnostic test that assesses the actual understanding level (i.e. "current level") of each child for their Language and Mathematical competencies. In cases where the current level is lower than the grade level of school, the program adapts to the child's learning level and through performance at each learning unit, the child progresses to the next unit or moves to a lower level learning unit or a remediation plan. In Figure 11, this child is successfully completing learning units (downwards) but needs to move to previous units at various junctures.

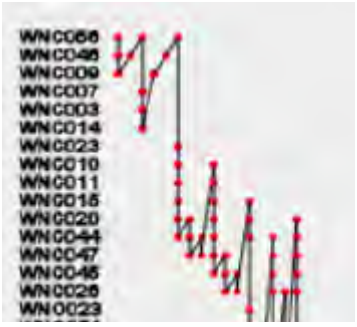

Figure 11. Learning path of learner

6. Concluding remarks

The best use of technology in elementary eduction is not for putting up fancy smartboards and projectors in classroom which typically deal with the delivery of material to students; but instead employing it towards a personalized and adaptive learning program with the right support system. Student attendance tracking, greater tracking of attendance and accountability of teachers by monitoring their login behaviour, involving parents in student behaviour through system-driven phone calls or texts, measuring

metrics like retention, usage, and performance in real-time are some ways that would allow for greater facilitation and efficiency of learning for children under the Education 3.0 generation.

Applying the principles of Education 3.0 in the context of elementary education is a complex one due to the nature of the target group. Catering to learners of different learning abilities, varying levels of reading, and requiring diverse skill sets to achieve the goals of the curriculum requires us to think beyond the framework of Education 3.0. While knowledge must be freely accessed and produced by the learner, the learner can't be left to moderate that knowledge on their own. Hence, the learning platform needs to be responsive to the access and creation of that knowledge to provide appropriate learning support and avoid a 'knowledge deluge'. In addition to this, one can't ignore the importance of a human intervention required with young learners. While advocating for technology-led learning, the changing role of the teacher and parent must be understood to allow for effective learning for every child. Through adaptive learning platforms like Mindspark, it is possible to provide young learners with the new learning experience synonymous with Education 3.0 that creates the incentives for a child to learn and for teachers to monitor and ensure that each child is performing at his/her best potential.

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