Group Spinner: Recognizing & Visualizing Learning in the Classroom for Reflection, Communication & Planning

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ABSTRACT
Group Spinner is a digital visual tool intended to help teachers observe and reflect on children's collaborative technology-enhanced learning activities in the classroom. We describe the design of Group Spinner, which was informed by activity theory, previous work and teachers' focus group feedback. Based on a radar chart and a set of indicators, Group Spinner allows teachers to record in-class observations as to different aspects of group learning and learning behaviors, beyond the limited knowledge acquisition measures. Our exploratory study involved 6 teachers who used the tool for a total of 23 classes in subjects ranging from Maths and Geography to Sociology and Art. Semi-structured interviews with these teachers revealed a number of different uses of the tool. Depending on their experience and pedagogy, teachers considered Group Spinner to be a valuable tool to support awareness, reflection, communication, and/or planning.

Author Keywords
Technology enhanced learning; collaboration; reflection; schools/educational setting; radar-chart; observation.

ACM Classification Keywords
H.5.0 Information Interfaces and Presentation: General

INTRODUCTION
For the past two decades there has been an increasing pressure on schools to focus more on the teaching of 21st century skills [17], integrate more technology in the classroom [30] and adapt to changing ideas about knowledge and learning [44]. This dynamic educational landscape has given rise to significant challenges in recognizing the impact of such changes on students' learning. Standardized assessments facilitated by 'high stakes' testing "encourage engagement with learning only insofar that it serves the achievement of the outcome" [21].

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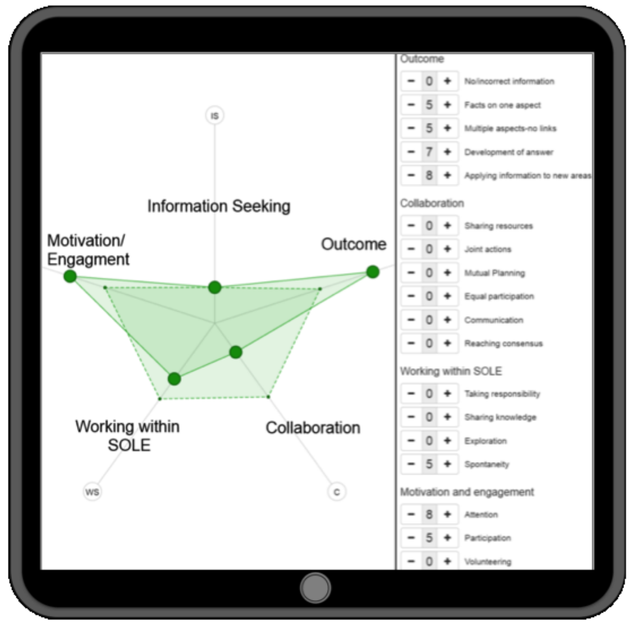

Figure 1. Annotated crop of Group Spinner's interface showing current and previous session graphs along with some indicators.

When it comes to technology based learning interventions, attempts to identify the impact of the use of technology within education must go beyond input-output tests and measure the broader pattern of use [8]. What is measured by standardized tests is, to a large extent, shaped by concepts of learning and knowledge developed prior to the digital age [44]. Technology's expected role – as a tool, a learning support or as an agent of change – and its expected contributions must be taken into consideration [35]. As McFarlane highlights, while some learning technologies may not (or are not intended to) support the acquisition of knowledge, their positive effects are on the development of 'skills' such as problem-solving, critical thinking, autonomy, confidence and information-building – highly desirable skills for members of modern society.

Thus a challenge for teachers is to incorporate and evidence a wider variety of learning opportunities in the classroom. New approaches and tools are needed to support teachers to reflect on their practice in these new settings, as well as recognize development in students' learning and learning behaviors beyond basic subject knowledge.

We describe the design process and present an exploratory study of Group Spinner, an interactive visualization tool based on a radar-chart and a set of indicators that allows teachers to record in-class observations of different aspects of group learning and learning behaviors. Group Spinner allows teachers (and potentially students) to tag positive observable behaviors according to a predefined rubric. These tags are incorporated in a radar-chart diagram that allows a quick recording and visualization of each group's performance with respect to the rubric (see Figure 1). With repeated use, Group Spinner can help teachers to track changes in students' learning/learning behavior with a view to visually communicate these changes to students and to inform planning and even pedagogy of future sessions.

Our research goals evolved during the research process from designing an evaluation tool for recognizing/ visualizing learning, to exploring its general use for teachers. We therefore conducted an exploratory study with six teachers, who used the tool for a total of 23 classes in subjects ranging from Mathematics and Geography to Sociology and Art. Our contribution is three-fold: 1) the introduction of Group Spinner as a digital tool to support teachers in technology-enhanced group learning activities; 2) the identification of insights into different use cases and the potential benefits of Group Spinner based on teachers' feedback in an exploratory study; and, 3) an understanding of teacher practices and concerns in technology-enhanced group-based lessons.

RELATED WORK

Collaborative technology in the classroom

Existing research on educational technology has mainly focused on understanding the role of technology from researchers' perspectives. That is, it overlooked how teachers can observe and understand the role of technology with regards to students' learning and behavior. This is unsurprising as evaluating learning resulting from the use of technologies targeting collaboration or higher level skills is not straight forward, and is normally done through extensive qualitative analysis (e.g. [19,26,28]). Dillenbourg and Jermann's work on classroom orchestration [9] aimed at providing a model for analyzing (and designing) technology use in the classroom. The model brings researchers' attention to a wide range of factors under the themes of teacher centrism, cross-plane integration, sequentiality, time management and physicality. However, its focus is more on how teachers orchestrate (manage) the classroom in the presence of technology than on students' learning side of things. Accordingly, while this model has been used by researchers looking at collaborative technology for the classroom (e.g. [24,34]), its use meant that it focused the analysis on understanding technology's role in supporting teachers in their 'orchestration' activities.

Taxonomies for assessing learning

A number of taxonomies have been developed to help teachers in assessing students' learning. The SOLO taxonomy (Structure of the Observed Learning Outcome) provides a framework which enables teachers to focus on quality of learning rather than quantity. It is defined as "a systematic way of describing how a learner's performance grows in complexity when mastering many academic tasks." [4:87]. SOLO is widely used by teachers as an effective tool to evaluate the learning outcome of an open task, where students are empowered to construct their own learning as opposed to reconstructing, or regurgitating, information they have already been given. Despite this, SOLO is still clearly focused on learning outcomes: that is, the knowledge and understanding of content. The learning processes that students engage in are disregarded, meaning that learning remains a knowledge-driven pursuit and the behaviors that enable students to effectively acquire that knowledge and understanding are ignored.

Bloom's Taxonomy of Educational Objectives [5,27] and its subsequent revisions [1] widens the scope of behaviors to observe. The usefulness of this template lies in it being able to support teachers in the design of curricula and classes which integrate plans for learning behaviors across three domains (Cognitive, Affective and Psychomotor) and to structure learning objectives in a progressive linear sequence moving from simple (remembering) to more complex (evaluating) behaviors. The increased use of digital technology in the classroom led to the development of Bloom's Digital Taxonomy [7], whereby different digital tools are aligned to the types of behaviors they can facilitate and where collaboration is a common thread running throughout. However, neither taxonomy recognizes the complex and dynamic nature of learning processes and, where technology is concerned, student-driven appropriation of the different tools available to them. The Digital Taxonomy also reduces characterizations of learning to a limited number of descriptors and tools, where the ultimate goal is assessment rather than leveraging the affordances of technology for learning design.

Starkey [44] highlighted shortcomings in both SOLO and Bloom's taxonomies and proposed the 'digital age learning matrix'. Her main criticism of SOLO taxonomy was its narrow focus on knowledge within the learner and that it did not pay due regard to knowledge creation and the connected nature of learning in the digital world. While Bloom's taxonomy addressed knowledge creation, it was considered too linear and not appropriate for use as a holistic tool. Starkey's matrix was developed as a research tool for the analysis and evaluation of teachers' activities that incorporates the use of technologies in the classroom. The matrix combines elements of observed use of technology (accessing information, presenting, processing information, and gaming) with levels of learning (doing, thinking about connection, thinking about concepts, critiquing and evaluating, knowledge creation and knowledge sharing). While more holistic, Starkey's matrix is still knowledge-oriented and does not adapt to the new rules/culture of more innovative classrooms by incorporating subjective aspects of learning (such as motivation and engagement) and, in regards to collaboration, only takes the perspective of knowledge sharing.

Other dedicated frameworks do exist for several different desirable learning skills and behaviours. For example, Limberg's [31] typology enables us to understand the characteristics of students' Information Seeking behaviour, and Guilloteaux et al. [18] addresses motivation and engagement. However, these do not address how such processes might coexist in students' learning experience.

Studies to assess learning

In an attempt to examine the impact of a statewide technology coaching program for teachers, Lowther et al's [33] mixed methods study found that while data based on students assessment and achievement records showed that gains in high-stakes tests were mixed, it was the classroom observations that revealed the changes in students' behavior. Such behaviors included more frequent engagement in research, project-based learning and use of technology. However, the classroom observations were carried out by researchers trained for a specific observation protocol of computer use, one that involved counting the number of times certain activities (such as cooperative learning and hands-on activity) occurred.

Moving from collecting data to presenting data, Ikuta and Gotoh [22] and Narumi and Gotoh [39] described the development and evaluation of a tool for visualizing learning outcomes. Their approach used radar chart visualizations of four learning outcomes: knowledge and understanding, domain-specific skills, generic skills and attitude. The approach has a superficial similarity to Group Spinner, but is in fact a highly structured and restricted *output-only* set of radar charts that are intended to create a visual summary of students' formal assessment results over the course of their undergraduate studies. The graphs are drawn automatically, created through a complex process of mapping proportions of different module assessment to each learning outcome and aggregating all the students' assessment results. The visualizations formed part of the students' e-portfolios and were intended to help students reflect on their learning, establish their own learning targets and become more independent in their learning.

While such approaches expand the measure of learning beyond domain-knowledge, the reliance on performance assessments serves to enforce the traditional emphasis on formal assessment. Dintzner et al. [10] used radar charts and curriculum mapping to visualize how the different courses in a pharmacy doctoral program contribute to the programmatic "big picture". This again is used as an organizational, output-only, visual tool to compare the contribution of the different courses to different competences rather than a tool for teachers or students.

Activity Theory

Unlike taxonomies and tools that are developed with specific goals in mind, Activity Theory (AT) [38,42] can

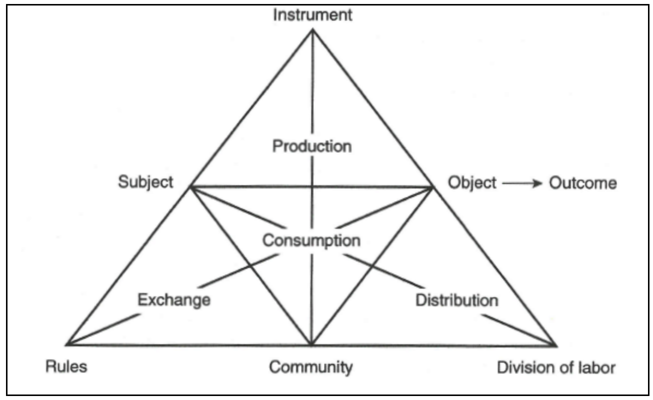

Figure 2. The structure of a human activity system [11:63]

provide a holistic framework for a wider exploration of learning processes. Developed originally as a general framework for studying human practices as a development process both at the individual and social level, it has been widely used in education where learning becomes the practice being studied [2,12,23,43]. AT's conceptualization of learning has three main elements: a subject (the learners); the object (task or activity); and a tool/instrument (a computer or a skill) [23]. Engeström, in his book 'Learning by Expanding' [11] developed the application of AT for education by incorporating the community (stakeholders in the learning process), the rules that govern the subject behavior within the community and the learning context, and the division of labor to achieve the objective (see Figure 2). While providing a framework for exploration, the abstract nature of AT makes it difficult to operationalize as a tool for teachers in their daily practice.

Finally, most previous research fails to accommodate student development over time, focusing instead on providing snapshots of students' performance – typically of one learning task. Indeed, the literature identifies a lack of teacher-oriented practical tools to scaffold the provision of more holistic views of students' learning and learning behavior; this is the key motivation for Group Spinner.

GROUP SPINNER: DESIGN AND DEVELOPMENT

Group Spinner's original motivation was to help teachers recognize and record progress in students learning and learning behaviors beyond the limited scope of assessment of knowledge acquisition. We drew on: 1) AT's view on learning [11] to provide a frame for identifying relevant observable behaviors; 2) the use of the radar-chart (e.g. [10,22,39]) as a tool to visualize measures of diverse behaviors in one chart as well as the change of these measures over time; and 3) existing taxonomies and guidelines to inform the development of a structured observation protocol for each behavior (a rubric). The design of Group Spinner was undertaken in five phases: 1) the development of the radar chart and its axes; 2) a focus group with teachers; 3) the development of an exemplar rubric; 4) a paper-based prototype trial; and 5) development of a fully functional digital prototype.

Activity Theory	Mapping to Group Spinner
Tool/Instrument	Skills in tool use: language, ICT, and thinking skills
Subject	Subjective factors affecting learning: motivation, behavior, confidence (identity)
Rules	Classroom dynamics
Community	Organization process
Division of labor	Collaboration
Object-outcome	Learning outcome

Table 1. Initial mapping of Activity Theory's concepts to Group Spinner axes.

Phase 1: The radar chart and its axes.

Table 1 shows our mapping of key elements of Engeström's characterization of the human activity system to the context of a technology-enhanced group learning activities. With the tool element, the aim has been to focus on the set of skills that students utilize when using the technology, as well as language and thinking skills, as tools to achieve their objective. AT views learning as a by-product of motives and goals, with subject-related factors such as motivation being considered as "integral to cognition, knowing, and learning, not some independent or peripheral factors that affect cognition" [42]. Accordingly, we initially mapped the subject element to a number of subjective factors including motivation, behavior, and confidence.

This mapping is then used as a basis of the first paper-version of the Group Spinner radar chart (Figure 3). It had five categories and a superset of 10 axes. The expected scenario of use was that teachers could select the axes on which they wish to focus on and create a copy for each group in the classroom. Through observation, the teacher could then place points on the different axes based on how well the performance of the groups were with respect to properties represented by the axes. These points are then joined together to form the first plot for each group in the class. In following sessions, teachers are to repeat the process for each group, based on the performance of previous sessions as well as observations of the current one. With repeated use, the teachers will be 'spinning' a web that visualizes each group's development over time.

Phase 2: Focus group

To gain early insights on the concepts behind Group Spinner, we conducted a focus group with a number of teachers from a local 'state' high school where group-based, technology-supported classes (in this case Self-Organized Learning Environment sessions, or SOLEs) are common practice. In SOLEs – a learning approach that is being used internationally (www.theschoolinthecloud.org) – students are asked a difficult open question, then given access to the Internet through a standard web browser and invited to work in groups to come up with an answer. Students work with no direct teacher intervention and are normally expected to present their answer at the end of the session, discussing it with both the teacher and other students [36,37]. The focus group, with six experienced teachers from this school, was conducted to understand how teachers evaluated such non-traditional sessions and to solicit their feedback on the first paper-version of Group Spinner. The discussion was audio recorded and transcribed. The transcript was thematically analyzed separately by two researchers (from technical and high school teaching backgrounds). Notes were then compared to identify key common themes. The main points highlighted by the teachers with regards to running non-traditional, self-organized sessions were:

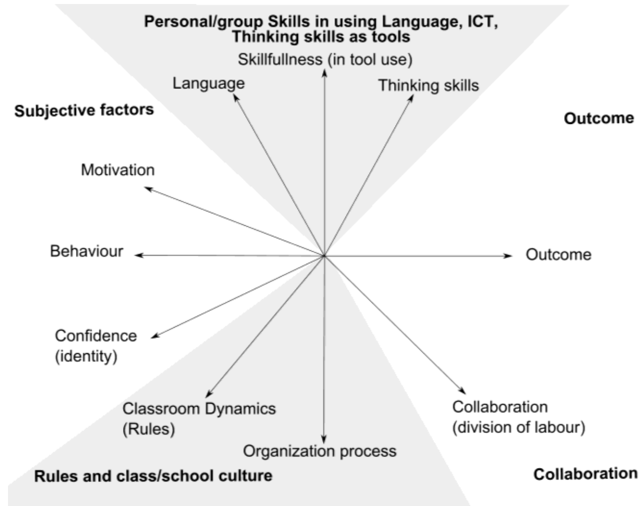

Figure 3. First version radar chart; superset of all possible axes as inspired by Activity Theory's activity triangle.

- *Outcomes:* the focus on outcomes is a major concern and impacts on their teaching and assessment.
- *Skills:* teachers, however, are still seeking to develop the students' ability to learn independently (individually or in groups) and to be able to evaluate different opinions (i.e., critical thinking skills).
- *Group dynamics* and the ability of students to switch groups and share ideas are seen as a positive thing.
- *Motivation* and moving from external to internal gratification are important factors for learning.
- The *culture of the class* (as set by the teacher and the school policy) plays an important role in the success or failure of any non-traditional teaching approach.

After introducing the paper prototype in Figure 3, the main points arising from the discussion were:

- *Awareness*: the different axes are important in making teachers and students 'aware' that there are outcomes that need to be considered alongside the traditional learning one. Having a 'debrief' using the tool or even hanging the diagram on the wall would be of benefit.
- *Reflection*: the tool can help teachers be more 'self-reflective'.

- *Communication*: the tool could be used as a "*good communication device, to communicate in your learning and get, for own personal target setting*". One suggested use case was to stop halfway through a session and have discussions such as "*Look at this. Which are we best at? Which are we worst at? Where are we making best progress? Where's the change?*"
- *Planning*: the tool could be used to plan sessions based on the previous ones to "*move things forward*".
- *Need for a rubric*: a taxonomy is desirable. The SOLO taxonomy was suggested as an example to help identify where to place a certain point on the axes.
- *Generalizability*: the potential benefits of the tools were seen as applicable for any group task, not confined to the self-organized learning environment context.

Finally, the teachers identified two major points of concern with the tool: *(1) Complexity*: There is a need to reduce the number of axes, to make it relevant to the activity at hand and increase its usability*;* 2) *Workload*: there was a concern about the additional effort required to use it in class, with one experienced teacher explaining that Group Spinner would just be "another layer" of work.

The focus group confirmed our view that too much emphasis is put on assessing traditional learning outcomes. It also confirmed the importance of the identified axes including subjective factors (motivation), skills (critical thinking), group dynamics (collaboration) and classroom culture. In addition to validating some of our motivations and design choices, the insights from the focus group changed how we viewed the potential use of the tool and accordingly our overall research goals. We no longer aimed to study Group Spinner simply as an evaluation tool, but to explore its general use to support teachers. Most importantly, the notion of using it as a reflection tool for the teacher and a communication tool to discuss and reflect on progress with students during or after sessions. Teachers also talked about using Group Spinner as a planning tool based on previous observations. This led us to make two important design decisions: 1) identify a core set of axes, and 2) provide a clear rubric for each axis.

Phase 3: An exemplar rubric

Self-Organized Learning Environment sessions present a good context to identify core axes and rubrics needed for Group Spinner, given its collaborative nature, reliance on the use of technology as a mediating tool (the Internet), its view of learning as extending beyond knowledge acquisition, and its need for minimum teacher scaffolding (allowing teachers to observe the class). For this context we used five axes: 1) *Information Seeking* (the use of the Internet/critical thinking as tools); 2) *Outcome*; 3) *Collaboration* (division of labour); 4) *Working within SOLEs* (context-specific culture/rules); and 5) *Motivation and Engagement* (subjective factors). These axes, along with their rubric, link to most of the main aspects covered by AT and reflect the key points raised in the focus group. The underlined numbered points in the following descriptions show the rubric's main observable indicators:

(1) Information Seeking

Students are increasingly relying on the use of the Internet in their assignments and in the classroom, making information seeking a key 21st century skill. In settings that promote learner independence, this is done with no—or minimal—guidance [36]. However, students are not necessarily equipped with effective information seeking skills, often stopping at the first information they encounter and building answers from the most readily available information rather than the most accurate or persuasive [20]. An inability to navigate the Internet to answer difficult questions and attendant frustration have been apparent in SOLE research [41]. Limberg's typology [31,32] was adopted as a criteria for observing effective information seeking. It reflects a clear progression of the sophistication of information management from: (1) <u>Fact Finding</u>, to (2) <u>Balancing Information</u> to find a position and finally to (3) <u>Scrutinizing and Analyzing</u>. This model is also applicable to digital environments because the affective and constructive elements of the process remain the same [29]. Moreover, these behaviors are easily observable by watching students and listening to their conversations.

(2) Outcome

Evaluating outcomes can be difficult for teachers in settings where diversity of information and outcomes are welcome. It is appropriate to consider both how much and how well students have learned, with Biggs and Collis [3] suggesting that the latter is much more challenging. Limberg [31] found that there was significant overlap between how students experienced information seeking and what learning outcome was achieved: students who predominantly worked within the simple fact finding stage typically obtained an outcome best described as fragmentary knowledge, while those scrutinizing and analyzing information showed critical assessment grounded in understanding and evaluation. This approach to constructing answers worked well with SOLO taxonomy [3], as it offers a framework within which teachers can evaluate the quality of an answer that they could not have anticipated. SOLO begins at the prestructural level, whereby students present: (1) <u>No or Incorrect Information</u>, to the unistructural, where they focus on (2) <u>Facts on One Aspect</u>, to multistructural where they offer (3) <u>Multiple Aspects but with No Links</u>, relational, where they show (4) <u>Development of an Answer</u> and finally extended abstract, in which they go beyond the information they found to (5) <u>Apply Information to New Areas</u>. Within this evaluative framework, students can gain credit for quantitative increases in knowledge up to the third level, at which point qualitative increases in understanding are required [4].

(3) Collaboration

When the teacher is not expected to be directly involved during group activities, students rely on their peers for support. A model examining the use of digital technology must therefore address the collaborative nature of knowledge creation and use [44]. However, as Wiener [45] puts it

"*Students put into groups are only students grouped and are not collaborators, unless a task that demands consensual learning unifies the group activity*". Students may appear to be working together to find a common answer by sharing some resources and doing actions together. However, when asked separately they may give different answers, indicating an absence of true attempts to engage in discussions aiming to reach a common ground and a consensus. Thus, reaching consensus is one of the key elements expected from effective group collaboration [45]. There are a number of observable behaviors that give positive indications that some type of collaboration is happening [13,15,45] of which we selected: (1) Sharing Resources; (2) Joint Actions; (3) Mutual Planning; (4) Equal Participation; (5) Communication; and (6) Reaching Consensus.

(4) Context-Specific: Working within SOLE

The rubric for 'Working with SOLE' was developed on the basis of numerous observations of SOLE sessions, the majority of which were at secondary school level (11-18 years). Over the course of more than 50 such observations it was clear both that students found the adjustment from 'traditional' lessons to SOLE challenging (see also [41]), and that teachers were also unsure of how this different style of learning might look in practice. This served as further evidence of the need for context-specific axes for Group Spinner. In self-organized settings, full responsibility for learning is handed over to students. Indeed, it can be difficult for them to understand how to deal with such an extreme change in their learning environment and we observed a default behavior of asking the teacher for help. The rubric for this axis was designed to address these key aspects of SOLE activities: (1) Taking Responsibility for their learning. The move from "knowledge hoarding" to (2) Knowledge Sharing [14] was also problematic for students as they often saw learning as a competition. Observations showed that students were typically happy to produce 'an' answer, regardless of whether they fully understood it or believed it was the best answer. Yet the concept of learning as a process of (3) Exploration, in which students could satisfy their curiosity, is central to SOLE. Another defining element of self-organized learning is (4) Spontaneity, although in our observations of students the rules and rituals of the traditional classroom were so entrenched that students would more readily adopt these in other settings rather than do something different.

(5) Motivation and Engagement

In learning sciences, motivation is an individual difference variable used interchangeably to describe why a student does something, for how long they are willing to do it and how hard they are going to pursue it. In terms of classroom practice, motivation is treated by teachers and students as associated with particular behavioral characteristics. The associated term 'engagement' is also often used to refer to different types of 'motivated behavior'. Teachers and students have very personalized definitions of these constructs that may or may not be rooted in something which is evidenced or recognized behaviorally. However, teachers' and students' use the terms generally to refer to: 'why, how long, how hard, how well, how proactively and in what way students engage in the learning process'. To provide some guidance through which motivation might be manifested in action, we draw on Guilloteaux and Dornyei's work on the Motivational Orientation of Language Teaching (MOLT) Observation Scheme [18]. MOLT was devised to gain information on students' 'situation-specific' motivation. It formulates an observation scheme, with specific descriptors of motivated and motivational-relevant behavior to help identify the quality of motivational experiences as they 'happen in time'. The observable 'motivated behavior' [16,18] includes three main variables/measures: (1) Attention and not displaying inattentive or disruptive behavior; (2) Participation and actively taking part in discussion linked to the activity; and (3) Volunteering to help students, groups and the teacher.

Phase 4: Paper-based classroom trial

A member of the research team used a paper-based version of Group Spinner (a radar chart with the five axes of the rubric only along with the rubric) to further inform the first digital version of Group Spinner. The researcher, who has experience in teaching, running and observing SOLE sessions, attended two such sessions to observe students and record these observations on the paper-based radar chart. The two main insights from this lightweight face-validity evaluation of the design were: (1) that the rubrics' details of observable behaviors were valuable in drawing the observer's attention to important and easily observable aspects of students behavior that may be otherwise missed; and (2) trying to keep a mental record of these behaviors and translating them into points on the graph was cognitively challenging. Functionality to tag behaviors as they are observed, which could then inform the graph, was seen as essential for the successful use of the tool.

Phase 5: Design and development of the digital tool

The focus group and the paper trial helped shape the original design ideas, and led to the following five additional design features for the digital version of Group Spinner (see Figure 4 and Figure 5):

1. *Two clear modes of operation*: (a) a rubric-based indicators mode, focused on tagging behaviors as they happen (setting indicator values, Figure 5); and a (b) graph mode which allows viewing and manipulating points on the graph (while optionally viewing the indicator values, Figure 4)
2. *Navigation*: (a) quick navigation between the axes and their indicators in indicators mode, reducing the need for scrolling by displaying main headlines for the indicators (and help for each indicator through a help icon); and (b) quick scrolling to a specific axis indicator using navigation links on the sidebar (Figure 5).
3. *Incremental control*: allow incrementing or decrementing a value for each indicator representing

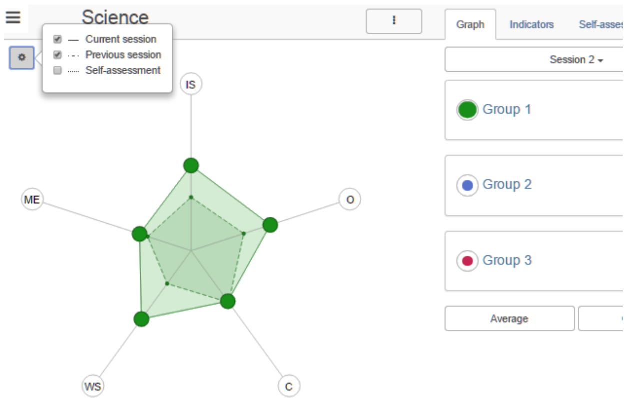

Figure 4. The graph mode shows the current/previous session graphs. The current graph points can be changed by dragging the control points along the axes. The right side allows changing sessions/ and groups as well as switching to the indicators mode.

either the number of times a behavior is observed, its quality, or both (depending on how teachers want to use it) (Figure 5).

4. *Making comparison*: (a) display the graph from the previous session for reference (Figure 4); (b) support comparing and averaging graphs for all groups for a certain session, or for all sessions for a certain group.
5. *Support multiple groups* (or students) per session with a quick way to switch between groups; allow the creation of new classes, sessions, and groups (Figure 4).

Group Spinner was designed to be available on most smartphones, tablets and PCs. It was developed as a responsive web-app using HTML5, CSS and JavaScript on the client side with Bootstrap 3, AngularJS and D3.js frameworks. The server side was built using Python with Pyramid framework and SQLAlchemy as an Object Relational Mapper. PostgreSQL was used for the database.

The tool was trialed with one teacher (T1) for two sessions before making it available to the other teachers. T1 provided early feedback which led to improvements in switching between the indicators and graph modes, and better presentation and navigation in the indicators mode.

GROUP SPINNER: USER STUDY

Group Spinner was used over 23 sessions in total (average of 50 minutes per session) by six participants, one primary school teacher (T1), four secondary school teachers from the same school (T2-T5), and a practitioner from the research team (T6) (Table 2). T2-T5 where from the school in which we conducted the focus group (only T4 had taken part in the focus group). Training teachers to use Group Spinner took approximately 10-15 minutes. Teachers ranged in experience, from one year of teaching with infrequent use of SOLEs to 10 years of teaching with regular use of SOLES over the past three years. We conducted semi-structured interviews (averaging 25 minutes each) individually with the

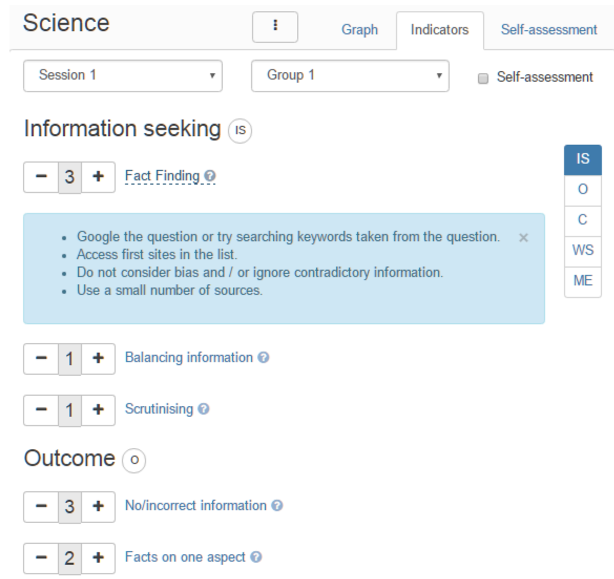

Figure 5. The indicators mode allows teachers to change the value of each indicator as well as display a clear description for each (help icon). The bar to the right allows for quick navigation to the desired set of indicators.

teachers, except for T6 (a member of the research team) who provided her feedback in written form. Interviews were audio recorded and transcribed for analysis.

Our goal was to explore both the different ways in which teachers use Group Spinner as well as its identified benefits to teachers and learners. This guided the questions of the interview, where teachers were asked about how they used Group Spinner, its perceived value, their perception of associated workload and their feedback on the ease of understanding the axes/rubric and the tool itself. The interview transcripts were analyzed separately by two researchers (from technical and high school teaching backgrounds) as with the focus group transcript. The analysis was first informed by pre-determined themes driven by the interview questions and subthemes emerging from the focus group & interview transcripts. We were keen to see if the teachers' feedback addressed the same themes that emerged from the focus group (awareness, reflection, communication, and planning).

A quote from T5 summarized much of the feedback we received: "*I think as a teacher it does **allow you to focus on those subdivisions** within what kids are doing in SOLE and **really think about them**…I think that **does then maybe alter your pedagogy** around what you do, what you ask kids to do. As I say one thing that came out for me was something that I was suspecting anyway, which is I think we need to ban that presentation, hard presentation methods. But I think, the crucial thing is what I would have done with it long-term around the data that is gathered. So then **have a really powerful conversation** with the kids*", then added "*It is a tool to allow you to **improve pedagogy and debrief***".

	Sessions	Age	Subject
T1	7	6-7	Art and SOLE
T2	3 x 2classes	11-12	Math
T3	2	13-14	Geography
T4	2	13-14	Sociology
T5	2	11-12	Geography
T6	4	10-15	Digital & foreign language skills (summer school)

Table 2. Sessions with Group Spinner

How? Observed use cases

(H1) *Post-class tagging (T1):* T1 struggled with the idea of using the interface "in situ" and settled on an approach where she would look at the indicators after the session: "*did I think they had done those things or not?*" She would then do the tagging, giving values based on memory and translating these into points on the graph. This is potentially a consequence of her being a tester for an earlier Group Spinner prototype, in which the navigation design had not been optimized. None of the other teachers reported difficulties using Group Spinner during a class.

(H2) *Tagging during the class (T2, T3, T6):* Teachers tagged behaviors as they were observed for each of the groups, on their tablets while walking around the class and talking to groups. T2 and T3 drew the graphs at the end or immediately after the sessions, based on the tags and their memory. T6 worked on the graph and the indicators during the session.

(H3) *Working on the graph directly (T2, T4):* Teachers walked around the class and talked to groups as normal, but adjusted the graph directly without using the indicators. T2 used Group Spinner for the first few sessions as in (H2), but once she got familiar with the indicators she switched to (H3). Similarly, T4 said that she initially used the criteria to help her understand what is related to each axis. T4 said that the process of tagging would take too much lesson time when she would rather be talking with students, whereas working directly on the graph was quite quick.

(H4) *Systematic observation cycles (T5):* T5 did systematic cycles around the six groups in his class every 10 minutes. This involved stopping at each group and asking them questions to identify and tag students' learning and learning behavior, and adjusting the graph accordingly at the end of each cycle. He reported that this was very intensive but he wanted to capture the rise and fall in students' performance throughout the session and not just have a final outcome (even though the tool only maintains the final state). This approach prompted discussions with groups such as "*I was really pushing that axis, I'm dragging it down again to get you to think about why that might be happening.*"

For all teachers, judgment for the tagging was based on both the quantity and the quality of the observed behaviors.

Why? Value for teachers and learners

(W1) *Awareness*: All teachers referred to the value of the tool in increasing their awareness about what was happening in the class. T1, T3, and T4 said that it brought their attention to, or made them "*more aware*" (T4) of things they may not think about (T1: "*I had never assessed any of those things that are on the spinner before.*") T3 initially questioned the value of the tool, but later said that she found that it helped her become aware of, and analyze, what each group was doing as well as concentrate on skills/behaviors that she might not think about otherwise. T1: "*...you have got the immediate impact of the graph. Then you have got your bits, statements down the side to back up what has been put on there*" (Figure 1 shows one of T1's graphs for sessions 6 with some of the indicators).

(W2) *Reflection*: T1, T2, and T5 described using the tool to help them think of, or 'reflect' on, their teaching and identify areas for development. T5: "*there is that obvious ability to then reflect on what you have done, the quality of your question. How you might adapt SOLE accordingly.*" However, T2 emphasized the importance of the tool at first use (to be aware of, and think about, the different aspects in the session) and not necessarily for longitudinal use (due to limited time, and the independent nature of her sessions).

(W3) *Communication:* While T1 (who taught 6 to 7 year olds), T3, and T6 did not use the tool to mediate discussions with the students, T2, T4 and T5 suggested that this could be one of the most important benefits of the tool. T4 mentioned that using the tool as a communication device helped students be "*reflective on how they've done*" across sessions and made them aware of what was happening with other groups. She emphasized that the tool helped make students aware of the process as "*it isn't an evaluation of what they did at the end, it's an evaluation of what they did throughout*". She also stressed the importance and benefits of the 'visual' representation in discussions with students: "*Sometimes there was things that I hadn't even picked up on that they then gave value to, which hopefully just having that conversation, but we would have had that conversation, it might have changed the focus of it potentially.*" T5 echoed T4's view on the importance of using the visual tool over a number of sessions to stimulate discussions with students and ask questions about what might be the reason for changes of the points on different axes. According to T5 "*I think that is perhaps its biggest strength actually. Predictably I think that would be where many teachers would find it to be really useful, the idea that they have got an evidence base, to talk to individual groups or even whole groups*". T2 only talked in terms of potential benefits. T1 and T4 saw potential in using the tool to talk to school's management "*to show that SOLE is a worthwhile thing to do*" [T1] as the tool helped look "*at the whole child*" rather than just ticking objectives.

(W4) *Track/Inform/Plan*: One of the most interesting comments was from T5 (quoted earlier) that the tool encouraged him to rethink how he facilitates self-organized

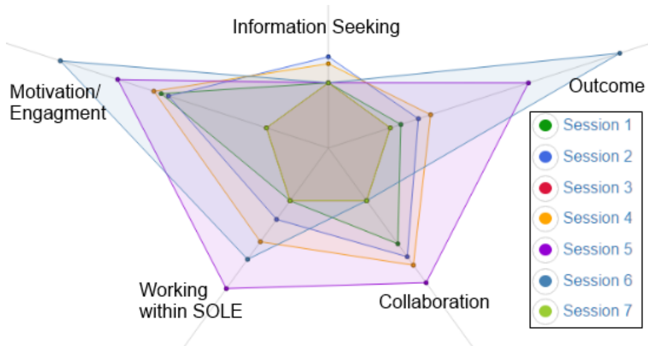

Figure 6. Graphs of 6 sessions by T1 with the yet unmodified graph of session 7.

sessions. According to T1, T3, and T5 the tool helped in recognizing progress, and thus could assist in identifying areas for development. "*I was able to use the spinner tool to show progress, then retract it…You would normally get an overall feeling for the direction of travel without seeing some of those barriers or red traffic lights.*" [T5]. T6 however, said that she used the tool at check points just to 'document things'.

(W5) *Repeated use*: T1 who talked the most about the value of repeated use, used Group Spinner for seven sessions with the same class. "***when I look back I can see immediately what the focus of that session was****…I need to make sure there are opportunities for making sure it is balanced all the way round*" (Figure 6). Other teachers who have used the tool two or three times with the same class talked about the benefits of comparing to a previous lesson, and the potential benefits for both the teacher in recognizing development, reflection, and planning (T1, T3, T5) and the students during post-session debriefings (T4, T5). T1 and T2 drew the graphs independently of previous sessions and then looked at the previous sessions for comparisons. Conversely, T3 made use of the graph from the previous session when creating a new one.

Did it add to your workload?

Teachers had different views regarding workload, correlating the load to their use of the tool in the study and how they may use it in the future. T1 said "*Well it is interesting to fill in so it is something I would be thinking about anyway.*" T3 said "*kind of did it within the lesson so not much*". T4 said that it was "*dead easy to use*", but might have thought otherwise had she worked on the indicators rather than the graphs directly. T6 claimed it would only add to the workload if she wanted to study the data and graphs afterwards. On the other hand, T2 and T5 said that the use of the tool did add to their workload, either because they wanted to have conversations with the students (T2) or because of a systematic approach to visiting and talking to each group (T5).

Ease of understanding and use

Whilst the feedback was mostly that the axes made sense and were easy to understand, the participants raised several issues: T1 said that she struggled with the outcome axis; T2 found the 'working within SOLE' indicator quite difficult, as she found the definition of a 'perfect scenario' unclear; and T5 said that he was not fully convinced by the motivation and engagement axis. Otherwise, apart from reports from three teachers about a few cases where updates where not saved (due to internet connection or multiple login issues), there were no comments on any usability issues with the app.

Challenges and teachers' wish list

The main challenge teachers reported relates to time management. T2 stated that she would be hesitant to use the tool in the future, as she would not be able to find the time to use it to engage with students, where she perceived that the tool was of most value. T3 stated that because in the beginning she was not fully used to the tool, she felt like at times it held her back from fully engaging with the students. T3 also expressed concerns in using it with classes that have behavior issues, where using the tool and managing behavior may come into conflict.

T2 and T5 wanted to have a record of the changing values for each tag during the session, enabling discussions with students about changes in their behavior/performance within it. T2 wanted a below zero indicator value for recording negative behavior. T4 asked for the ability to have school-wide customizations of axes. Finally, T1 and T6 talked about there being value in providng the ability to attach notes/photos to the graph axes (or the indicators). According to T1 "*a lot of early years programs work like that.*"

DISCUSSION

During the design process, the focus of the tool shifted from a tool to help with evaluation to a tool to recognize and reflect on learning. The focus group and study then extended this to include communication and planning. Even though only T4 took part in the study and focus group, the six teachers' comments from the study confirmed the same 'value' themes of awareness, reflection, communication and planning. T4, who was skeptical in the focus group and expressed concerns that the tool would only add another layer of work, became much more positive about it. She mentioned that working directly on the graph was 'dead easy' and she was among those who particularly valued the visualizations as a tool to scaffold conversations with the students. The feedback from the teachers highlighted a great variety in how teachers have or would use Group Spinner in terms of breadth, depth, and frequency/time span. Four different use cases were identified, mostly determined by the teachers' pedagogical approach, their goals behind using Group Spinner, and the time/effort they were willing to invest in using it.

An interesting conclusion that can be drawn from the study is that teachers' experience in settings like SOLE, their pedagogy and the age of the students involved could be linked to the extent to which the teachers perceived the main value of the tool as a student development tool, or a personal (teacher) development tool. T2-T5 (all having at least one year experience running SOLE sessions) focused more developing students over and above traditional learning outcomes. The visual nature of the graphs and the overlay with previous sessions was seen as a way to support meaningful conversations with the students. Students were debriefed about their learning by *connecting the outcome to the process*, which the tool can help to identify as a series of ups and downs rather than an overall direction of travel. T1's interpretation of the tool, on the other hand, seems to be more evaluative than developmental, and more for her own purpose than for the students – potentially due to her working with younger students. It's likely that this view would also apply to other teachers who may be less experienced in playing a scaffolding role in non-traditional classes. However, even experienced teachers mentioned that the tool could have an impact on their planning and pedagogy, because reflection on their own practice would inevitably follow from recognising how students were developing. Even using the tool for only two sessions helped T5 reshape his future pedagogy. In this way, and even for these teachers, Group Spinner becomes a development tool for them as well.

In addition to visualizations being powerful tools to enhance communication [6,40], there was a recognition of the fact that the indicators provided a useful language to communicate with students about their learning. However, there was some concern about the need/time required to 'train' students in this language. This would be most powerful where the whole school 'buys in' to the language together, so that students understand that the behaviours they develop are transferable. The rubrics could be particularly useful here, bringing clarity to what the behaviours look like in practice and making them tangible. In general, the teachers' feedback highlighted the need for tools that allows visual representation of students' performance and behavior to allow for more effective teacher-student dialogue. These need not necessarily be in the form of separate tools, but as features integrated into other technologies developed for the classroom as highlighted by previous work on classroom orchestration [9] and recommendations for designing technologies for the classroom [25].

A limitation of our study is that some teachers only managed to use the tool for two sessions. However, T1, who had a chance to use Group Spinner for seven sessions, was the most enthusiastic about Group Spinner's long-term benefits with repeated use as she saw this firsthand. Furthermore, our initial focus was on group activities for two reasons: 1) students thinking and learning is more visible, and thus observable through their discussions when they work in groups, and 2) it is easier for the teacher to observe a limited number of groups than every student in a large class. This limits the use of the tool to group activities where groups are maintained across sessions. However, T1 decided to focus on a number of individual students who, while still working within groups, are representative of the whole class. In this sense, and if the teacher's objective in using the tool is personal (reflection and planning) then this can be a useful alternative to observing and tracking groups. Due to the limited time that the teachers were able to use the tool, none of them used the students' self-assessment feature (apart from one teacher who only experimented with it). However, T2, T3, T4, and T6 commented on its potential to inform discussions based on comparisons between student and teacher graphs.

As the teachers themselves identified, the tool is not only for use in SOLE-based learning activities (and was not designed as such) but rather for any context where there is need to recognize students' development beyond subject knowledge. This applies to technology-free contexts and to traditional group learning activities, in which case information-seeking can be replaced by the most relevant skill for that activity. Accordingly, our future plans are to allow teachers to create, share and use different templates (axes and rubrics) based on their context of use (a functionality repeatedly requested by T4) and look at the benefits/practical challenges of long-term use. Two other interesting directions of enquiry are exploring the tool's use for reciprocal-communication when students use the tool for self-evaluation in addition to the teacher, and looking at the effects of different visualization options on the quality of such communication (e.g. sliders to navigate through the different layers in time, or reformatting the visualizations to show the value of each aspect across a time axes).

CONCLUSION

We presented the design process and findings from an exploratory study of Group Spinner, a digital tool to help teachers recognize the impact of collaborative technology-enhanced learning activities in the classroom. All six teachers who used the tool over 23 session in total confirmed that they saw value in using the tool in their classroom around the themes of increased awareness, reflection, communication and/or planning. Teachers' experience and pedagogy as well as external factors such as time limitations and students' age can be linked to whether the tool was mainly perceived as a development tool for the student or the teacher. The feedback showed that the tool was flexible enough to allow for different styles of use depending on teachers' goals behind using the tool. Teachers' feedback also shows that technology to support teachers should not only be focused on content delivery, assessment, and administration, but rather expand in scope to address their wider challenges and needs in the classroom as exemplified by the values associated with Group Spinner.

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