

Artefact-Centric Activity Theory as an analytical framework for systematising teachers' evaluations of app use

TOR INGE VETHE

Keywords: artefact-centric activity theory, mathematics education, educational apps, possibilities, limitations

Educational apps are increasingly used in primary mathematics classrooms, yet there is limited clarity on how to analyse teachers' evaluations of app-mediated activity. Existing tools for evaluating apps often emphasise predefined criteria for usability or quality assurance and provide limited support for analysing teachers' reflections on app use in their mathematics lessons. In this study, I explore whether and how Artefact-Centric Activity Theory (ACAT) can be operationalised for analysing teachers' evaluations of app use in classrooms. To illustrate the analytical possibilities of ACAT, semi-structured interviews with two third-grade teachers in Norway were analysed. The analysis suggests that ACAT may offer a way to identify the possibilities and limitations teachers described in relation to mathematical content, app design, learner activity, and classroom interaction while using apps. This suggests that ACAT may be operationalised to provide insights from interview data about participants' evaluations of app use.

Teachers' use of digital tools in mathematics education is often described as complex (Calder & Murphy, 2023) and in need of stronger support for classroom practice (Griffith et al., 2020). However, according to Dorris et al. (2024), less is known about how teachers and students make sense of using digital tools in mathematics classrooms. Part of the reason may lie in limitations of existing approaches for analysing participants' views (Larkin et al., 2019; Papadakis, 2021). In this article, I explore whether and how Artefact-Centric Activity Theory (ACAT) (Ladel & Kortenkamp, 2013) can be used for examining participants' evaluations about the possibilities and limitations of app-mediated mathematical activity. In doing

Tor Inge Vethe

Western Norway University of Applied Sciences, Bergen, Norway

Vethe, T. I. (2026). Artefact-Centric Activity Theory as an analytical framework for systematising teachers' evaluations of app use. *Nordic Studies in Mathematics Education*, 31 (3), 43–61.

so, I examine what ACAT makes visible when teachers' interviews are the data material, thereby extending how ACAT has been used previously.

Ladel and Kortenkamp (2013) introduced ACAT as a framework to analyse learning environments with apps for primary mathematics education. They considered that by placing an artefact, such as a specific app, at the centre of the analysis, the artefact's role in mediating children's learning of specific mathematics became more transparent. Since then, it has been adapted as an evaluation tool for mathematical apps that can be used by teachers (Larkin et al., 2019). Other frameworks, including rubrics and checklists, have also been developed to analyse app integration in classrooms (Harrison & Lee, 2018; Papadakis, 2021). Like REVEAC (Papadakis et al., 2017), the Mobile Apps Selection for Science (Green et al., 2014), and the App Checklist for Educators (Lubniewski et al., 2018), most evaluation tools are primarily designed to support app selection and quality assurance by helping teachers evaluate whether or not, or to what degree, an app meets predefined criteria (Papadakis, 2021), before using them in the classroom.

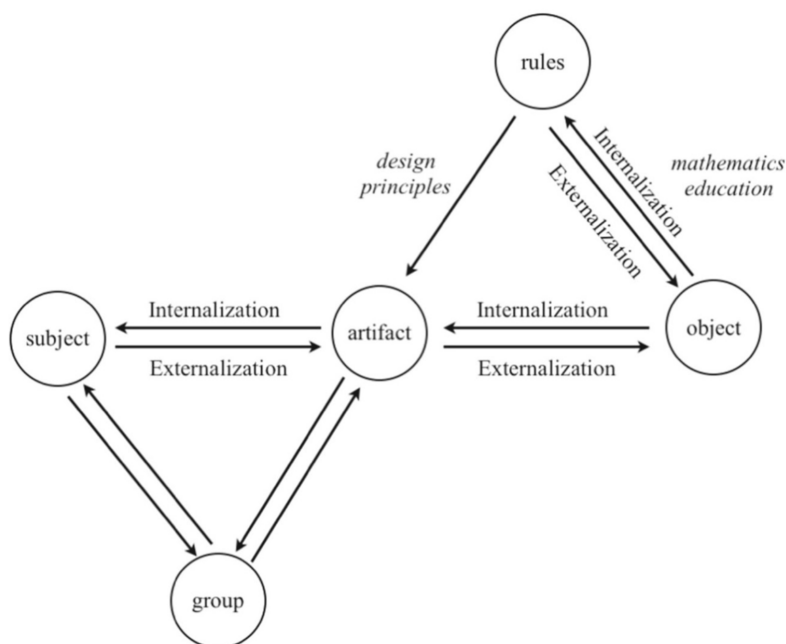
ACAT (Ladel & Kortenkamp, 2013), by contrast, supports a focus on app-mediated mathematics activity as situated and relational by including components of mathematics classroom context in the evaluation. This mathematics-specific inclusion makes ACAT a relevant candidate for examining app-mediated mathematical classroom activity, which is considered situated and relational. While researchers previously have used ACAT to evaluate apps and analyse app environments (e.g. Ladel & Kortenkamp, 2016; Kortenkamp, Ladel & Larkin, 2025; Moyer-Packenham et al., 2019; Vee & Meaney, 2025; Welch et al., 2022), it does not seem to have previously been operationalised to analyse interview data about how participants reflect upon using apps in mathematics lessons.

The purpose of this study is to explore whether and how ACAT can be used as a framework to analyse participants' evaluations of app use in mathematics lessons. Interview data from two third-grade teachers is used to discuss the potential of ACAT as an analytical tool, particularly in terms of whether ACAT could offer insights into what participants identify as possibilities and limitations when discussing app-mediated mathematics activities. In the next section, I introduce Ladel and Kortenkamp's (2013) ACAT framework, review its previous applications in research, and outline in the methodology section how ACAT was operationalised to explore teachers' perspectives on app-mediated mathematical classroom activities.

ACAT as an analytical framework

Ladel and Kortenkamp (2013) introduced ACAT as a framework for understanding app-mediated mathematical activity. The framework helps focus on how a Subject (student) engages with a mathematical Object (topic), mediated by the Artefact (app). As illustrated in figure 1, this relation is further specified through two nodes. The Rules node focuses on the app's design principles that structure access to the Object by constraining or enabling certain actions within the app. The Group node focuses on the social organisation of activity, including peer interaction and teacher mediation (Ladel & Kortenkamp, 2013).

Figure 1. *The ACAT model (Ladel & Kortenkamp, 2013)*



As shown in figure 1, Ladel and Kortenkamp (2013) placed the nodes in two interconnected triangles. In the top triangle, Artefact–Rules–Object, the emphasis is on how apps shape what mathematics is made available, through how the app is structured and how the mathematics is represented. The artefact is considered to structure the learners' opportunities to engage with the mathematical object, by how it is internalised and externalised according to the app's design principles. For instance, feedback and progression rules can foreground particular ways of working

with multiplication by rewarding speed and accuracy over strategy explanation, and by controlling what representations and actions are made available (e.g., Moyer-Packenham et al., 2019; Bullock et al., 2021). In the second triangle, Subject–Group–Artefact, the emphasis is on how app-mediated activity is shaped by the social organisation around engaging with the artefact, including how peers and teachers support, constrain, or redirect learners' work (Ladel & Kortenkamp, 2013). Participation with the app can shape what learners focus on and how they express meaning through actions, gestures, and talk, as shown by Welch et al. (2022).

Ladel and Kortenkamp (2013) stated that the interaction of internalisation and externalisation of the mathematical object allows a process-oriented viewpoint on a learner's mathematical competence. Internalisation focuses on how the mathematical object is integrated into the artefact and the learner's understanding. Externalisation concerns what the app requires learners to do, through their actions and representations of what is made available through the app, to highlight the mathematical meaning internalised by the artefact. In ACAT, as apps make available possibilities which could enable or constrain certain actions, the expected externalising actions can be seen as foregrounding particular properties of the object (Ladel & Kortenkamp, 2013). Internalisation and externalisation are therefore processes that can contribute to analysing how app design and participation shape learners' opportunities to engage with the mathematical object. This is exemplified by Larkin et al. (2019), who operationalised the Rules node by treating feedback and progression as part of an app's rule system, since these features define acceptable responses and possible next actions. Accordingly, in this study, the arrows connecting the nodes were treated as analytical relations, including the processes of internalisation and externalisation represented in the model.

ACAT in earlier research and its analytical potential

This section has two purposes. First, it shows how ACAT has been used in earlier research and what this suggests about ACAT's analytical potential. Second, it identifies what remains unclear when considering how to analyse teachers' interviews of app-mediated classroom activity.

In previous research, ACAT has been used to analyse how mathematical content is made available to learners and how mathematics is presented through the apps. Larkin et al. (2019) used ACAT to evaluate the geometry apps Pattern Shapes and Click the Cube, with attention to mathematical representations, feedback mechanisms, and the depiction of geometric properties such as transformations, coordinates, angles, and symmetry. Their work showed that ACAT could support an analysis of

how an app's design shaped the mathematical activity made available to learners. In a larger study of 193 students in Grades 2 to 6, Moyer-Packenham et al. (2019) used ACAT to analyse 12 digital mathematics games. Based on pre- and post-tests, interviews, and video recordings of students' gameplay, they identified eight design-feature categories that were salient in students' app activity. Similarly, in a qualitative study of fifth-grade students using two virtual-manipulative apps on touchscreens, Tucker and Johnson (2017) examined how students responded to how mathematics was presented in the apps during app use. With ACAT, they examined how attributes of both the students and the apps changed during use. They argued that children and apps mutually adjusted the mathematical challenge. More recently, Kortenkamp et al. (2025) used ACAT in a case study of a six-year-old student engaging with the app Fingu to analyse how app use supported the student's learning of part-whole relations. Taken together, these examples are relevant to the present aim because they show that ACAT has been used to investigate app design, mathematical content, learner activity, and participation. However, the focus was on the value of the app, particularly its design, rather than on the participants' own evaluations.

ACAT has also been used to analyse the relationships between different aspects of using apps. In studies such as those by Moyer-Packenham et al. (2019) and Larkin et al. (2019), the emphasis was largely on how app design structured access to mathematical content. Here, ACAT was used to connect design features, such as representations and feedback, to the kinds of mathematical activity that became available to learners. In other studies, the analytical emphasis was on participation when using the artefact. For example, Welch et al. (2022) used ACAT to focus on what mathematics students noticed in apps and how they expressed their understanding. This was identified from their gestures, talk, and small-group interactions. Analysing a child's understanding of part-whole concepts while using an app (Fingu), Kortenkamp et al. (2025) used ACAT to focus on both the app's design and the surrounding classroom context, to highlight the child's internalisation and externalisation of the mathematics. These studies suggest that ACAT is analytically useful because it can relate the presentation of mathematics in the app to the activity that develops from its use. At the same time, Christiansen (2024) points to a limit by questioning whether teacher mediation is sufficiently visible in the framework. Focusing on the relations between aspects of the app use indicates that ACAT has possibilities for more interconnected analysis of teachers' evaluations about how apps support and constrain mathematics learning in classrooms.

What is less clear in previous research is how ACAT can be operationalised to gain understanding from interviews about classroom app use. Previous research analysed app reviews, students' gameplay, video material of app use together with interviews with learners, and evaluative discussions. In several cases, the primary concern was the app itself or learners' observable activity with it (e.g. Kortenkamp et al., 2025; Larkin et al., 2019; Moyer-Packenham et al., 2019). In contrast, Vee (2023) used ACAT as a lens to analyse how preservice kindergarten teachers' evaluations of apps could provide insights into their understandings of children's opportunities for *danning*, the Norwegian term for cultural formation or *bildung*. The data in this study came from screen recordings of 13 small-group discussions in which beginning preservice kindergarten teachers evaluated different apps. Her aim was to analyse what those evaluations revealed about the preservice teachers' views of children's *danning*. Vee and Meaney (2025) extended this line of work by using ACAT to analyse preservice teachers' evaluative accounts from practicum assignments, before discussing how these could be related to socio-political influences. However, these analyses focused on the issues identified by the researchers, not on what the participants themselves wanted to highlight. Therefore, it remains less clear how relations between aspects of app use can be analysed in participants' interviews from their own point of view, particularly regarding what they considered to be possibilities and limitations in learning mathematics.

From this earlier research, it seems that ACAT offers a way of connecting app design, mathematical content, learner activity, and classroom participation within one framework. Ladel and Kortenkamp's (2013) argument that placing the artefact at the centre of activity theory helps to "locate the various areas of didactic and pedagogic design that have to be taken into account" (p. 8) makes the framework seem relevant for analysing participants' own accounts of app use in mathematics lessons. In the next section, I discuss whether and how ACAT can be operationalised for that purpose, using interview data from two teachers to illustrate possibilities. As ACAT highlights the relations between mathematical content, app design, learner activity, and classroom participation, the teachers' reflections were first organised using the node labels, with attention to their relations to the artefact, and then considered across the two triangles.

Illustrative data

I used three semi-structured interviews with two third-grade teachers as illustrative material. The teachers were experienced primary practi-

tioners who had previously used tablets, laptops, and GPS tools in their mathematics teaching. They worked in a school in a municipality where tablets had become part of ordinary classroom practice and, therefore, could provide relevant data about evaluating app use in everyday teaching. The interview format used open-ended questions about their teaching background, general tablet use, and experiences with mathematics apps, aiming to support their reflections and to build on each other's responses. This fits with Creswell's (2014) description of semi-structured qualitative interviewing as suitable when participants are invited to elaborate on their experiences in their own terms.

During the interviews, the teachers referred to four apps used in their mathematics teaching: Kikora, Multi Smart Øving, Mattemaraton, and Salaby. These apps were provided by the municipality (the teachers could not download additional apps) and were primarily designed for individual use and varied in purpose (practice, fluency, learning universe) and design (feedback, progression, rewards). The teachers reported the most frequent use of Kikora and Multi Smart Øving because they offered practice across topics such as arithmetic and patterns. Salaby was described as a broad learning universe with strong visual design and a broad range of subjects, while Mattemaraton was described as offering tasks focused on fluency by providing rewards.

Operationalising ACAT to analyse teachers' app evaluations

The analysis was developed as an exploratory operationalisation of ACAT (Ladel & Kortenkamp, 2013), inspired by how ACAT has been used in previous studies (e.g. Christiansen, 2024; Kortenkamp et al., 2025; Vee, 2023) and ACAT review guides (e.g. Etzold et al., 2018; Larkin et al., 2019). In the interviews, the teachers often discussed several aspects of app use within the same statement. The teachers' statements were first organised using the node labels, while the analytical focus was on how the relations between the artefact and the aspects represented by each node were described. Relations across the framework were then considered through the two triangles.

In developing the operationalisation, I followed earlier research (Christiansen, 2024; Vee, 2023) and categorised statements as referring to the Object node when the teachers reflected upon what mathematical content and topics they considered to be made available by and foregrounded in the app. Larkin et al.'s (2019) guiding question in their evaluation form, "What mathematical content seemed to be foregrounded by the app?", supported this categorisation.

Statements were considered to be referring to the Rules when the teachers commented on how mathematics was presented in the apps, including reflections on design features such as feedback mechanisms, task sequencing, difficulty levels, permitted actions, and reward structures, shaping how students could act on the mathematical object, in alignment with the work of Moyer-Packenham et al. (2019) and Larkin et al. (2019). The guiding question was, "How is mathematical content presented for students to act upon?"

Statements were categorised as referring to the Subject when the teachers described the students and their actions while using the apps, inspired by Welch et al. (2022). The guiding question was, "How did the teachers describe the students and their actions while using the apps?"

Statements were categorised as referring to the Group node when they concerned how app use shaped peer and teacher participation and dialogue during an activity, such as in the work of Kortenkamp et al. (2025). The guiding question was, "How did the app use shape participation during the app activity?"

In this operationalisation, the Artefact node was not used as a separate coding category in the same way as the other nodes because it functioned as the mediating centre of the analysis. As highlighted by Ladel and Kortenkamp (2013) and Larkin et al. (2019), the app is the mediating artefact across the analysis and is central to the relations represented within the two triangles. For example, when a teacher described how immediate feedback in an app encouraged trial-and-error strategies, the app was analysed not as an isolated object of comment, but as the mediating artefact connecting the rules, learner activity, and the mathematical content. When a statement seemed to involve more than one node, I examined how these aspects were related through the Artefact and within the two triangles. The two triangles were then used to examine how these relations were expressed in the teachers' accounts. This second step was important because the value of ACAT for interview data lay in examining how the relations between content, design, learner activity, and participation were expressed in the teachers' accounts. This second step was informed by earlier ACAT research that has highlighted relations between components, such as along the main axis and through the two triangles (e.g. Kortenkamp et al., 2025; Ladel & Kortenkamp, 2013; Larkin et al., 2019; Welch et al., 2022). What was specific in this study was to make this relational reading a separate step in the operationalisation of the teachers' interview accounts.

As many of the teachers' evaluations of app use in their classrooms seem to focus on possibilities and limitations for mathematical activity or participation, I used ACAT to determine what kind of possibilities

and limitations the teachers considered the apps provided and how they might be related.

Analysis

In this section, I outline how ACAT can contribute to analysing the interviews. Table 1 provides an illustrative overview of how the ACAT node labels were used to identify and organise what the teachers described as possibilities and limitations in app-mediated mathematics activity. The table presents what was identified through the node-wise reading, before the relations between the nodes are examined through the two triangles.

Table 1. *Node-wise overview of possibilities and limitations in teachers' evaluations of app use*

ACAT NODE	GUIDING QUESTION	ILLUSTRATIVE POSSIBILITIES	ILLUSTRATIVE LIMITATIONS
OBJECT	<i>What mathematical content seemed to be foregrounded by the app?</i>	Practice in multiplication (arithmetic fluency) Pattern recognition (e.g., "see patterns") Measurement (length on screen)	Narrow mathematical scope with strong emphasis on basic arithmetic (multiplication)
RULES	<i>How is mathematical content presented for students to act upon?</i>	Immediate feedback supporting persistence/self-correction Correct-answer progression (motivating for some students) Time limits supporting lesson routines Visual examples and audio/video support guide attention	Correct-answer progression constrains some learners (unable to proceed without help) Time limits encourage speed over reflection Lack of explanatory feedback (signals correctness without supporting understanding) Unlimited attempts encouraging trial-and-error
SUBJECT	<i>How did the teachers describe the students and their actions while using the apps?</i>	Persistence through repetition "until they mastered them" Motivation through progressing to more challenging levels	Heavy text load as a barrier (esp. for learners with reading difficulties) Guessing/trial-and-error actions ("tap and try again", repeating the same answer) Teachers' broad categorisations of learners when talking about expectations of who benefits/struggles
GROUP	<i>How did the app use shape participation during the app activity?</i>	Spontaneous peer support (help interpreting tasks) Sharing strategies/comparing answers and post-task discussions	Copying answers without reasoning Teacher stepping in after tasks presented (reduced access to students' thinking during activity)

Object

The Object node refers to the mathematical content that the artefact makes available to learners (Ladel & Kortenkamp, 2013). In the data, the Object node was used as an entry point to the relation between the Artefact and the mathematical Object, and was used to identify what the teachers described as supporting and what they saw as limited or missing in the apps they used in the classrooms.

Both teachers mentioned the relevant mathematical content provided by the apps. The focus of these apps mostly seemed to be about practice-oriented work and how they could support students' fluency in arithmetic, especially multiplication, an important topic for grade 4. One teacher explained how she considered that one of the apps allowed students to "see patterns" in multiplication and algebra, noting some students proceeded directly to multiplication activities. Both teachers also referred to tasks in which "you have a symbol in the place of a number", and students had to find out "which number is hidden behind that symbol". Geometry and measurement were also mentioned, but these comments were shorter and less developed in their accounts in this interview. The other teacher highlighted geometry as central to her idea of an ideal mathematics lesson with apps, saying, "In any case, it's about geometry. About shapes. Shapes, and it's about concepts". She also mentioned, as an example of mathematical content accessible via apps, how students "work with measurement" was connected to their ability to measure lengths directly on the screen. In contrast to their more detailed reflections on times tables and arithmetic operations, these comments appeared as more isolated expectations of app use. Seen in relation to the broader range of content in the Norwegian Grade 3 mathematics curriculum (Ministry of Education and Research, 2020), these accounts suggested that the teachers' evaluations of app use in this interview focused on a relatively narrow selection of mathematical topics.

By focusing on what mathematical content the teachers considered the app foregrounded, the Object node provides insights into their reflections on what topics the apps used in their school made available. In this way, the Object node-lens can highlight teachers' evaluations regarding the mathematical scope of app-mediated activity.

Rules

The Rules node refers to design principles embedded in the artefact that structure how learners gain access to the mathematical object by regulating which actions are enabled or constrained (Ladel & Kortenkamp, 2013). In this analysis, attention was directed to how these design prin-

ciples connected the Artefact with the Object and shaped the actions available to the Subject. The Rules node was used to examine how the teachers evaluated the ways mathematical content was presented in apps for students to act on.

Both teachers commented on the apps that included immediate feedback as they considered that it could support students' persistence and self-correction, by indicating to them whether they were on the right track. One teacher described this as useful for students being able to keep working "again and again and again," when the task structure encouraged repetition. The embedded design principles that required a correct answer before students could move on, were described as motivating for some learners, particularly those students who they consider benefited from step-by-step advancement, while the same structure was described as constraining when students could not proceed without teacher help. This suggests how the features of the subject, the learner, affected the teachers' evaluations of the value of certain design principles.

The teachers also described how reward structures and repeated chances to respond could shift students' attention away from the mathematics itself. One teacher explained that in one app, students were often more concerned with "collecting the coins and getting through the level," so that solving the multiplication task became "secondary". The same teacher also described how some students approached app tasks with what she called a "game approach," where "if they miss the first one, okay, then they take the next and then the third, and maybe that one will be right". She added that, because "we always get another chance," this could end in guessing rather than reflection. The other teacher similarly noted that "some try the same answer five times". This suggests that the teachers evaluated design features such as feedback, progression, rewards, and repeated attempts in terms of how mathematical content was presented for students to act on.

Another aspect of the Rule node that was evaluated by the teachers was about expectations to do with time. While one teacher described short app sessions as useful for organising classroom routines, the other noted that students did not always stop when the time was up. They both described students saying, "I just need to finish" or "Yes, but I'm in the middle of something now," even after being told that there was "one minute left". These comments suggested that the same rule structures that supported pacing and flow in classroom activity could also make transitions more difficult. These comments suggest that evaluation of design principles could also be affected by aspects of the Group node which were to do with how the digital tasks were connected to expected ways of working together in classrooms.

In evaluating the apps, the teachers also referred to limited explanatory feedback. In such cases, apps were described as signalling whether an answer was right or wrong without supporting students in understanding why, which the teachers considered to be a constraint.

Based on these examples, it seems that the analysis of the Rules node can provide insight into these teachers' evaluations of how the mathematical content was presented in the apps for students to work with. It highlighted how the teachers described feedback, progression, reward structures, repeated attempts, and time limits as shaping students' engagement with mathematics. The Rules node also made visible how the teachers evaluated app design in relation to how the value of feedback and progression depended partly on how different students were described as responding to these design features. This indicates that the Rules node may offer a useful lens for analysing participants' reflections on how app design structures possibilities and limitations in app-mediated mathematical activity.

Subject

The Subject node refers to the learner who engages with the mathematical object mediated by the artefact (Ladel & Kortenkamp, 2013). Using the teacher interviews, I focus on the relation between the Subject and the Artefact by examining whether and how the teachers referred to learners and described students' actions while using the apps.

The teachers' descriptions of the students focused on what they did while using the apps. As was discussed in the rule node, the teachers referred to students who wanted to continue until they had "mastered" the tasks and to students who were motivated by moving on to more difficult levels. Other comments concerned actions the teachers described as less productive, such as when some students were said to "just tap and try again" or "put in the same answer five times." They also contrasted students "who have done many tasks and asked about difficult things" with "others who do only a few tasks and don't care if it's right or wrong."

The teachers also referred to students in broad groups. They talked about students "who generally do well at school" to be "more productive using apps", whereas students having reading difficulties were said to need more support to understand what the app required. The teachers referred to reading demands as a barrier, explaining that some did not want to continue because "there is too much text ... they know they won't manage."

Therefore, the Subject node lens highlighted how the teachers described both possibilities and limitations in how different kinds of

learners engaged with app-mediated mathematics activity. When students persevered through repetition and willingness to continue with more difficult tasks, the teachers seemed to consider that engagement with the apps was supportive of their learning. However, they considered that students' use of guessing to gain correct answers in the apps limited their possibilities for learning. Struggling students were connected to those who had low involvement in using the apps, sometimes as a result of the app's reading demands. In this way, the Subject node made it possible to identify how the teachers evaluated how student characteristics had an impact on their actions when using the apps.

Group

The Group node refers to participation around the artefact (Ladel & Kortenkamp, 2013). In the analysis, attention was directed towards how this social organisation connected the Subject with the Artefact and shaped opportunities for participation. The Group node was used to examine whether and how teachers' evaluations of app use included reflections on dialogue, peer support, and teacher participation in mathematics lessons. As noted in the Rules node, the evaluations also included discussion of how apps fit into classroom expectations around transitioning between tasks.

Both teachers described app use as sometimes providing possibilities for peer interaction around tasks. They referred to situations in which students "look at each other's tablets", then they might "help each other", adding that one student might say, "I was just explaining the task". The teachers also described that some of these exchanges concerned how to arrive at the correct answer. One teacher said that students talked about "what you have to do to get the right answers", while the other gave the example that students might tell each other, "you actually have to move the coins" to solve the task. These teachers described peer support and task-oriented dialogue around individual app use as contributing to students' learning possibilities.

In contrast, the teachers also noted that some students "just give each other answers", and one teacher linked this to the students focusing on getting to the next task, rather than about learning. The teachers also described how app use limited teacher participation. One teacher explained that "the teacher has to step in and resolve it afterwards, instead of being part of it". This seemed to be connected to concerns about apps often making it difficult for the teachers to see how students were thinking mathematically while they were working. Thus, ACAT provides pos-

sibilities for identifying how the teachers evaluated the kinds of participation the apps seemed to support or restrict.

The Group node made it possible to identify that the teachers' evaluations of app use included reflections on dialogue, peer support, and teacher participation in mathematics lessons. These evaluations considered the possibilities and limitations provided by app use against their expectations. They described possibilities for supporting learning, such as students helping each other, explaining tasks, and sharing ways of solving them. Limitations on possibilities for learning occurred when students were considered to copy each other's answers without reflecting on the mathematics, when app use reduced possibilities for dialogue, and when app use limited teachers' access to students' mathematical thinking. Identifying aspects of the Group node in the interview data could provide insights into teachers' evaluations of participation around the app.

Interconnection across ACAT

The node-wise organisation helped identify what the teachers described in relation to mathematical content, app design, learner activity, and participation. However, several statements did not concern only one aspect of app use, but connected mathematical content, design, learner activity, and participation within the same evaluative accounts. For example, the teachers often commented about multiplication in connection to reflections about feedback, progression systems, rewards systems, and possibilities for repeated attempts. This suggested that the teachers did not only focus on evaluating what mathematical content the apps included, but also how that content was presented for students to act on and their possibilities for learning. Such connections become visible when focusing on the Artefact–Rules–Object triangle. Within the Artefact–Rules–Object triangle, these connections made it possible to identify how the teachers related the mathematical content made available in the apps' design and how they considered what students were expected to take up from that content (internalisation) and how they were expected to respond to it through the app (externalisation).

In a similar way, comments about students "just tap[ping] and try[ing] again", "put[ting] in the same answer five times", "look[ing] at each other's tablets", or "giv[ing] each other answers" were not just descriptions of learners or their participation. From the node analysis, these comments suggested how the teachers related students' actions, participation around the artefact, and what these actions seemed to indicate about students' engagement with the mathematics. Viewed through the Subject–Group–

Artefact triangle, these comments brought into view how the teachers related students' app-based actions (externalisation) to the participation around the artefact, and how these actions were described as suggesting particular forms of engagement with, or understanding of, the mathematics (interpretations of internalisation).

In this way, reading across ACAT added something beyond the node-based analysis and organisation. It made it possible to examine how the relations represented in the framework were expressed in the teachers' evaluations, for example how teachers connected content, design, learner activity, and participation within the same evaluations in the interviews. This is relevant to the purpose of the article because it suggests that ACAT may offer a relational way of analysing interview data about app use in mathematics lessons.

Discussion and concluding remarks

The purpose of this study was to examine whether and how ACAT (Ladel & Kortenkamp, 2013) could be used to analyse participants' interviews about app use in mathematics lessons. Interviews with two teachers about their experiences of using apps in their classrooms provided illustrative material for exploring what ACAT could make visible in such accounts. Based on the analysis, ACAT appeared to offer a way of organising participants' evaluations by distinguishing between mathematical content, app design, learner activity, and participation, and making visible what aspects of app-mediated activity they attended to and how these were described in relation to one another.

In previous studies, ACAT has been used in analyses of app design (e.g. Larkin et al., 2019), analysis of videos of students' app use (e.g. Kortenkamp et al., 2025), and students' interactions with apps in classroom settings (e.g. Tucker & Johnson, 2017; Welch et al., 2022). In contrast, I applied ACAT to interview material to examine what the framework could make visible in participants' evaluations of app use. The analysis suggested that ACAT could support attention both to node-specific aspects, such as mathematical content and its presentation in apps, and to relations across nodes, such as how participants described learner actions and what these seemed to suggest in terms of internalisation. This was relevant because the data were participants' own evaluations of how actions and participation around the app were described, rather than observable data, such as video recordings of classroom interactions. In this way, ACAT appeared to support the analysis of interview material about what participants identified as possibilities and limitations using apps. More specifically, ACAT provided insights into their reflections

about the complexity of app-mediated mathematics activity by connecting content, design, learner actions, and participation within the same evaluative accounts.

In relation to the purpose of the present study, ACAT seemed to offer an analysis that combined mathematical content and classroom integration, which can be considered different from frameworks primarily designed for supporting app selection. Rather than mainly assessing whether an app meets predefined criteria, as in rubrics such as REVEAC (Papadakis et al., 2017), or focusing on teacher knowledge or levels of technology use, as in TPACK (Mishra & Koehler, 2006) and SAMR (Puentedura, 2006), ACAT made it possible to analyse how participants described relations between mathematical content, app design, learner actions, and participation within the same evaluative accounts. In this study, the value of ACAT therefore did not only lie in making categorisation possible, but in supporting a relational interpretation of participants' evaluations of app-mediated mathematics activity.

At the same time, using ACAT with interview data highlighted some issues. The node labels provided an important entry point for organising participants' evaluations and identifying what aspects of app-mediated activity they attended to. However, while using the node labels supported identifying and organising participants' accounts, the analytical value lay in examining how the aspects represented by the node labels were related to the artefact and to one another through the two triangles. This suggests that, while node-based coding was useful for structuring the material, much of the interpretive value lay in reading across nodes through the triangles. It may also be that interview questions more explicitly based on the ACAT nodes, as in earlier work operationalising ACAT for app evaluation (e.g. Larkin et al., 2019), could support participants producing statements that are easier to organise and analyse using the node labels.

Overall, ACAT appeared to offer a useful framework for analysing teachers' interview accounts about app use in mathematics lessons. Its potential in this study lay in examining how they related mathematical content, app design, learner activity, and participation within the same evaluative accounts. In this way, a relational analysis can support questions about how participants connect what mathematics they consider apps to make available, how that mathematics is presented for students to act upon, how students are described as responding, and how participation around the app is evaluated. This suggests that ACAT may support a more relational analysis of app-mediated mathematics activity than frameworks primarily designed for app selection or technology integration.

Acknowledgement

This work was supported by the Research Council of Norway (grant number 322970).

I would like to thank my supervisors, Rune Herheim and Tamsin Meaney, at Western Norway University of Applied Sciences, for their time, expertise and support with this article.

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Tor Inge Vethe

Tor Inge Vethe is a PhD candidate in mathematics education at the Department of Language, Literature, Mathematics and Interpreting at Western Norway University of Applied Sciences. He has several years of experience as a primary school teacher and in the municipality school administration. His main research interests concern teacher and student voices related to learning opportunities when apps are used in mathematics teaching and learning.

tor.inge.vethe@hvl.no