Using the Number Line and Educreations in a Second Grade Classroom: A Collaborative Action Research Project

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ABSTRACT
The inquiry-oriented and cyclic process of action research can lead to the innovative use of technology and instructional strategies to improve teaching practice, particularly for beginning teachers. This action research project examined the impact of the number line and Educreations on second-grade students' verbal and written explanations of three-digit addition and subtraction operations using whole numbers. Pre- and post-surveys were implemented to examine how the second-graders worked on the given three-digit addition and subtraction problems. The students' perceived value of using the number line indicated that the majority of the students found the number line helpful. Classroom observations and the students' use of the number line and Educreations indicated that student skills for solving and explaining the process of addition and subtraction methods increased as demonstrated in the post- assessment and the student videos.
Keywords: Number Line, Educreations, Action Research

INTRODUCTION
Children need to be competent in the four operations of whole numbers to enable them to understand rational numbers (Behr & Post, 1992) and related mathematical knowledge and skills. The U.S. National Mathematics Advisory Panel (2008) recommends the use of the number line model to help provide learners a key link between conceptual and procedural knowledge. The conceptual understanding of place value and the number line can help support the acquisition of more advanced mathematical competencies. Technology tools such as Educreations can support student learning and mathematical understanding as well as supporting the teacher as a formative assessment tool. This present study describes a collaborative action research project that took place in an urban K-12 classroom.

LITERATURE REVIEW
The Number Line
Research "points to the value of using visual representations of mathematics concepts for supporting the development of students' mathematics understanding" (Woods, Geller, & Basaraba, 2018, p. 230). A critical precursor for mathematical competence is the ability to mentally generate and understand the number line structure (Case, 1996). "A number line is a visual representation that illustrates the order and magnitude of numbers" (Woods, Geller, & Basaraba, 2018, p. 230). It follows an analogical format allowing for automatic and efficient processing of numerical values (Newcombe, 2002). Children's ability to accurately place numerals on the number line is predictive of their later mathematics achievement (Geary, 2011; Siegler & Booth, 2004).

Siegler and Booth (2004) found that kindergarten, first and second-graders' number line estimations correlated strongly with their math achievement test scores: "Individual differences in number-line estimation correlated strongly with math achievement test scores, improved estimation accuracy proved attributable to increased linearity of estimates, and exposure to relevant experience tended to improve estimation accuracy" (p. 428). The researchers stated that "the smaller a child's percent absolute error of estimates, the higher was that child's achievement scores" within each grade (p. 434).

Other studies (e.g., Siegler & Opfer, 2003; De Smedt, Verschaffel & Ghesquière, 2009) indicated that kindergarten and first-grade performance in arithmetic tasks using the number line is related to achievement in grades 1 and 2 respectively. In a longitudinal study, Halberda, Mazzocco, and Feigenson (2008) found that performance on a non-symbolic number comparison task in grade 9 was retrospectively predictive for mathematics achievement in each year from kindergarten to grade 6. Research regarding children's ability to place fractions on the number line strongly correlates with their math achievement (Hamdan & Gunderson, 2017). Hamdan and Gunderson (2017) found that the number line training with second and third-graders led to the transfer of an untrained fraction magnitude comparison task when compared to area model training.

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Using the number line helps children "develop greater flexibility in mental arithmetic as they actively construct mathematical meaning, number sense, and understandings of number relationships" (Frykholm, 2010, p. 4). "Research suggests that visual representations, like a number line, support students' development of number sense by helping them create a mental representation of the order and magnitude of numbers" (Woods, Geller, & Basaraba, 2018, p. 229). The use of representations such as diagrams may be easier for children who tend to represent numbers on the structurally similar number line than for children who tend to represent numbers verbally or as digits (Schneider, Grabner & Paetsch, 2009).

The number line is used "to support reasoning about the operations of addition and subtraction as children construct representations of additive compositions (e.g., 50 + 23) or decompositions (73 - 23)", and using the number line helps students "develop qualitative understanding of numerical value in relation to lengths along the line" (Saxe, Diakow, & Gearhart, 2013, p. 344). It "allows students to engage more consistently in the problem as they jump along the number line in ways that resonate with their intuitions, and "they are able to better keep track of the steps they are taking, leading to a decrease in the memory load otherwise necessary to solve the problem" (Frykholm, 2010, p. 7).

The number line is a way to visualize the concepts for students to understand what place value is. Using the number line can help learners understand the foundations of place value and how manipulating numbers can change it. Place value is the quantity represented by the position of a digit relative to the decimal ("Place-Value Concepts," 2015, p. 2). Children's understanding of "place-value structure constitutes a building block for later arithmetic skills" (Dietrich, Huber, Dackermann, Moeller & Fischer, 2016, p. 502). The number line approach as an instructional strategy to explain the process of addition and subtraction can help clear up the misunderstanding of the standard algorithm the students may have.

"The influence of conceptual knowledge on students' mathematical competence is straightforward… it enables the learner to see relations between different pieces of knowledge…" (Schneider, Grabner & Paetsch, 2009, p. 361) which also can help with problem-solving strategies and transfer strategies between related types of problems. Conceptual knowledge is "knowledge of the core rules and principles as well as of their interrelations in a domain" (Goldstone & Kersten, 2003; Hiebert, 1986; Rittle-Johnson, Siegler, & Alibali, 2001, as cited in Schneider, Grabner & Paetsch, 2009, p. 360). Using the number line as an instructional method can help students develop mathematical models in the process of their conceptual learning.

Gravemeijer (1999) suggests exposing the students progressively developing models. First, as models of a realistic situation, second as models to represent computation strategies, and third as mathematical tools to think with when solving problems. "Models that emerge from the students' activities, supported by classroom interaction, are explicitly used to lead to higher levels of mathematical thinking" (Fosnot, 2007, p. 8). "The number line may be a particularly effective representation for fraction learning because its properties sign with the desired mental representation and take advantage of pre-existing spatial-numeric biases" (Hamdan & Gunderson, 2017, p. 587).

Educreations

Educational applications have gained the attention of K-12 teachers for classroom use in order to motivate students and support their learning. "With a growing emphasis on performance-based assessment, digital tools are needed to ensure students are provided with opportunities for explaining their knowledge and ideas in a variety of ways" (Johns, Troncale, Trucks, Calhoun, & Alvidrez, 2017, p. 56). According to Johns et al. (2017):

Educreations (https://www.educreations.com) is an app that serves as an interactive whiteboard and screencasting tool through which users can add videos, voice-overs, images, and annotations to instructional presentations in an effort to explain a concept or idea. The virtual whiteboard includes a variety of ink colors for students to draw or annotate. The app is easy to use and allows both teachers and students to create videos, craft presentations, and illustrate ideas (p. 56).

Students can use the Educreations app "to write out the strategies they use to solve math problems, take pictures of their manipulatives, and record their voices explaining the process" (Hillman, 2014, para. 2). The app allows the students to save their work and help review and reflect on their thinking. Educators can share videos with the students' parents or in their e-portfolio work (Hillman, 2014). In science and math classrooms, students can use the Educreations app to create a video explaining the steps of a science experiment or solving a math problem (Johns et al., 2017).

Particularly mathematics and language classrooms have found value educational value in screencasting tools

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such as “Explain Everything and Educreations to support mathematical understanding” (Prescott & Damian, 2018, p. 286). "In the language arts classroom, students can use the Educreations app to create a digital story using pictures, videos, and narrations that demonstrate their thinking in a creative way" (Johns et al., 2017, p. 57). In an English as a Second Language classroom, Educreations videos were used to "introduce students to English vocabulary that facilitates the mapping of new lexical items onto their existing conceptual framework in Arabic" (Jackson III, 2015, p. 6). In a first-grade classroom, the app was adopted to support children's narrative of the literature using drawings, audio and video (Möller & Ferguson, 2017):

Educreations is an ideal way to capture students’ extended responses not only as finished visual products but also as rich processes. The app recordings preserve the in-time thinking behind the visual response as it simultaneously records individual narration or dialogue/discussion and the evolving visual response image (p. 58).

In this action research project, several number line apps were considered to use for supporting student learning and practice of addition and subtraction. The classroom teacher/action researcher chose the Educreations app for the student practice with the number line, and addition and subtraction methods. Her review of the educational apps concluded that Educreations included features that best fit for her students’ and the classroom activities she had planned to implement. According to her, the app was easy to learn and use, and the availability of screencasting features of this tool offered opportunities for increased learning for her class.

Action Research

Classroom action research provides a path of learning for instructional practice through a series of reflective stages that facilitate the development of progressive problem solving (Bereiter & Scardamalia, 1993). Action research is “a spiral process that includes problem investigation, taking action and fact-finding about the result of action” (Ghazala, 2008, p. 46). The purpose of action research is “for practitioners to investigate and improve their practices" (Hendricks, 2006, p. 3). This research method seeks to solve an instructional problem using a systematic inquiry approach that includes reflexivity and focus on the practical to improve teaching and learning.

Action research is teacher-initiated and teacher-directed with the end goal of improving practice and ultimately improving schools (Sagor, 2000). The practitioner “develops a plan, implements the plans (acts), systematically observes the results of the actions, and then reflects on the results” (Putman & Rock, 2018, p. 7). A key feature of action research is its cyclical or spiral nature. The cyclical process “serves as a formative assessment that results in modifications or revisions to the original plan as necessitated by what the data revealed, leading the researcher successively closer to t e objective of the research” (Putman & Rock, 2018, p. 5). This cyclic nature of action research can lead to creative and innovative development of instructional strategies and techniques to improve teaching. The process helps the teacher understand him/herself, the students, the learning context and the action steps for improvement of their practice (Putman & Rock, 2018).

The action research process has been tackled by many scholars. Kurt Lewin is considered to be the first scholar who has conceptualized and coined the term “action research.” His paradigm for action research began with an objective to reach, then proceeded in a spiral of stages of analysis, fact-finding, conceptualization, planning, execution; then a repetition of the whole cycle; indeed, a spiral of such circles (Lewin, 1946).
Stringer ‘s (2007) “Action Research Helix” includes looking, thinking, acting phases that continually lead to the next action process and repeated over time. Riel’s (2019) model includes identifying a problem studying and planning, taking action, collecting and analyzing evidence, and reflecting. Similar to other models, this model also continues with the next cycle in a repeated process. Others’ such as Bullough and Gitlin’s (1995) three-phase process included:

- Phase 1: Identify and write up a concern or issue; collect baseline data. In light of the data, reconsider and reformulate the issue and write a question.
- Phase 2: Write and implement an action plan; gather data; analyze data.
- Phase 3: Assess the plan in the light of the data analysis (p. 181).

Sagor (2000) developed a seven-step inquiry process for action research (pp. 3-4): 1) selecting a focus, 2) clarifying theories, 3) identifying the research questions, 4) collecting data, 5) analyzing data, 7) reporting results, 7) taking informed action.“ Whitehead and McNiff’s (2006) research cycle of “action-reflection” consists of five disciplined and systematic steps: observe, reflect, act, evaluate, modify, and move in new directions.

Hendricks’ model includes “Reflect, Act, Evaluate, Reflect, Act, Evaluate” (Putman & Rock, 2018). The action

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research models proposed emphasize the cyclic and systematic approach to introducing innovations in teaching and learning that can ultimately lead to curriculum improvement. Engaging in classroom action research can support beginning teachers to help develop expertise in their teaching. Collaborative action research becomes a tool beginning teachers can use to inform and improve practice and engage in ongoing expertise development (Sternberg,1998, as cited in Mitchell, Reilly, & Logue, 2009).

The Project

Action research project was initiated in the College of Education at a Midwestern higher education institution. The project directors worked with K-12 schools to identify teachers who would be interested in conducting action research in their classrooms. After the call for proposals were made to the teachers, university faculty and teachers worked in pairs to conduct action research in the teachers' classrooms. Faculty's responsibility was to help guide the teachers with their action research projects. The action project directors provided guidelines and timelines for the teachers and the faculty via email or face-to-face meetings. At the end of the project timeline, action researchers shared their projects with the K-12 and higher education institutions in a poster session organized at this Midwestern college of education.

As a new teacher in her second year of the teaching profession, this classroom teacher was interested in implementing a different strategy other than the standard algorithm when working on three-digit addition and subtraction operations of whole numbers. Her curriculum included teaching the students three-digit addition and subtraction using whole numbers. Her observations led her to think that the majority of the class seemed to have a lack of understanding of the foundations of the place value and how manipulating numbers can change it.

Conceptual understanding of students' arithmetic operations is key to helping students achieve better with their addition and subtraction methods. The number line as a visual representation of numbers can help students' develop a foundation and conceptual understanding of place value; thus, help them successfully work on arithmetic problems. The action research project provided an opportunity to examine the impact of the number line and Educreations on students' verbal and written explanations of addition and subtraction methods.

The action project took place in a second-grade classroom (ages 7-9) at a Midwestern urban school. "... action research is usually conducted in a unique setting with a comparatively small sample (for example, one classroom, one school)" (Sagor, 2007, p. 156). Fifteen and seventeen students participated in the study using the empty number line for addition and subtraction operations respectively. The school administration supported and encouraged the teachers to use educational technology in their classroom. The classroom teacher was technology savvy and incorporated iPads and other technology into her teaching frequently. The students had not used the Educreations program prior to this study; however, they were comfortable using their iPads and technology applications available to them.

The following Common Core Standard was used for this lesson in this second-grade classroom:
CCSS.Math.Content.2.NBT.B.7: Add and subtract within 1000, using concrete models or drawings and strategies based on place value, properties of operations, and/or the relationship between addition and subtraction; relate the strategy to a written method. Understand that in adding or subtracting three-digit numbers, one adds or subtracts hundreds and hundreds, tens and tens, ones and ones; and sometimes it is necessary to compose or decompose tens or hundreds. ("Common Core", 2017, para. 1).

Prior to the introduction of Educreations, the following instructional strategies were implemented with the number line for teaching 3-digit addition and subtraction operations.

- Addition: The students start with a 3-digit number on the number line. The students then decompose the second addend. After decomposition, they add on the number line by place value (hundreds, then tens, then ones).
- Subtraction: The students start with a 3-digit number on the number line. The students then decompose the subtrahend. After decomposition, they subtract on the number line by place value (hundreds, then tens, then ones).

The project included pre- and post-assessment results and written explanation of how the students solved the given three-digit addition and subtraction problems, Google forms questionnaire about their perceived value of using the number line, and the instructor observation and reflection of the student-made Educreations videos. The second-graders were given pre- and post-assessments prior to and after the introduction of the number line for addition and subtraction operations respectively. The post-assessments took place two weeks after the pre-assessments. The assessments included the students solve and write out how they've worked on the given three-digit addition and subtraction questions. The traditional paper-and-pencil method was used for all the pre- and post-assessments. The class received the same addition and subtraction questions. The students were not

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prompted to use any particular strategy solving the problem. The assessment results were compared examining whether or not the students gave the correct answer and that they had the correct explanation of the process in solving the given problems.

During the Educreations assessment, the students were prompted to draw the number line and write on the app’s whiteboard while they verbally explain their method for finding the answer. The length of the videos averaged around one minute. These self-made videos served several purposes: as a formative classroom assessment tool, a reflection tool for this action research study, and supporting conceptual learning through the students’ own explanations of the process. The classroom teacher watched the students’ use of the Educreations and how they solved their given addition and subtraction question. In addition, at the end of the classroom activities related to the topic, a Google forms questionnaire was distributed to the students inquiring about their perceived value of using the number line with three-digit addition and subtraction problems.

FINDINGS AND DISCUSSION

The classroom assessments and observations suggest that using the number line as an instructional method along with the students’ self-made videos using Educreations improved student knowledge and skills working on three-digit addition and subtraction operations. The addition pre-assessment found that 5 out of 15 students got the right answer while 2 students could explain how they solved the question correctly. In the subtraction pre-assessment, 13 out of 17 students got the correct answer, but only one student could explain the process. It was found that on both pre-assessments, the students did not write much about how they solved the given problems. The addition post-assessment showed that all the students got the right answer and all could explain the process correctly. In the subtraction post-assessment, all the students gave the right answer, but 13 could explain the process correctly.

When solving the pre- and post-assessment questions, the students were not prompted to use the number line to explain the process of adding and subtracting three-digit problems. It was found that even though not all the students used the number line in the post-assessment, they were able to correctly explain their process of solving three-digit addition and subtraction operations. The post-assessment responses showed that the students were able to describe in-depth about the actual value of the place value.

During the students’ assessment of their use of Educreations with the number line, each student was given a different addition or subtraction problem to solve using the number line and the Educreations app (Figure 1). Close attention was given to the questions so that the difficulty level did not vary. The students drew the number line on Educreations using their classroom iPads and solved their addition or subtraction problems explaining their thought process verbally and marking and writing on the app whiteboard. Teacher observations noted that the students did not experience any difficulty drawing and writing on the app whiteboard while verbally explaining how they solved the given problem.

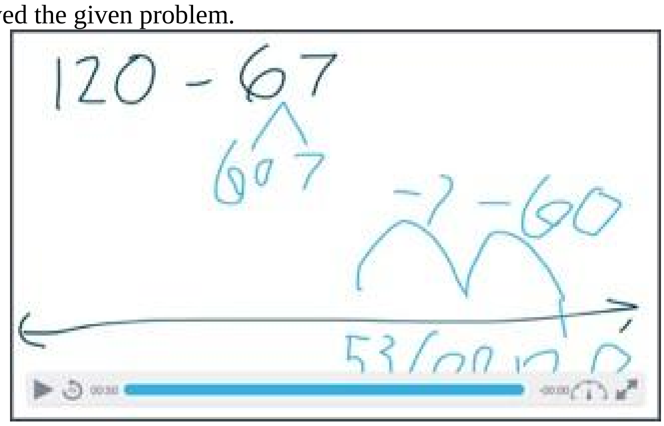

Figure 1. Using the number line to explain a subtraction problem with Educreations.

As expected, the students did better on addition compared to subtraction questions. The Educreations videos allowed the second-graders to concretely put into practice visualizing the number line, the place value, and how addition and subtraction problems can be solved. It’s important to note that on the traditional paper and pencil assessments, the students did not do much explaining of their given math operations. On the contrary, when using Educreations. they gave more in-depth information through their drawings and markings on the number line and narration of the process they took for their addition and subtraction operations. It was also observed that the students used correct terminology for the mathematics operations using the number line. Teacher

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observations of the Educreations videos gave the teacher richer information and perspective into the students' conceptual understanding or areas the teacher need to scaffold further into the future lessons.

In order to assess the students' perceived value of the number line for solving addition and subtraction problems, a Google forms questionnaire was implemented. The responses showed that 75% of the students marked "Yes" when asked: "Does the number line help you with addition?". 56.3% of the students marked "Yes" to the question but about subtraction. 18.8% versus 31.3% of the participants responded "No" for the help of the number line as an instructional strategy to solve addition and subtraction problems respectively.

The second-graders were asked two additional questions: "Why do you like or not like the number line?" and "What have you learned from the number line?". The responses included that they liked using the number line because it helps them count faster, it's fun to use, it's easy, and it takes a long time but it helps with finding the right answers. For example, two of the responses were: "It is easy and you break the numbers apart and then you add them." "I like the numberline because it makes it easier to answer by breaking it down and you can go down by tens, fiftys [fifties], hundreds."

The students who didn't like using the number line responded: "I like base ten better.", and "I don't like the numberline because I usually don't get the right answer." These responses indicate that the students in majority liked the number line for addition problems, but not particularly for subtraction problems as they find subtraction to be harder. This was confirmed by the percentage of students who marked "Yes" to the question when asked if they liked using the number line for addition and subtraction operations. 75% of the students liked using the number line for addition problems whereas 56.3% liked using it for subtraction questions. For example, one student wrote: "It is hard to subtract. I like that it [the number line] can help you add by going forward by hundreds and tens." The finding that subtraction is more difficult than addition is consistent with previous research as it's related to children's cognitive development at this age. "Counting down requires an ability to count backward while keeping track of the number of backward steps. The demands of the simultaneous processes help to explain the difficulty of subtraction relative to addition" (Baroody, 1984, p. 203).

Regarding the students' perceived value of using the number line, the students reported that the number line helped them understand about place value and the reasons for using the number line in addition and subtraction operations. Their responses included "I learned [that] the numberline shows you how to take away by place value.", "I learned that you add using hundreds, tens, and ones.", and "I learned how to subtract by counting backward by place value.". Other responses included "It can be hard or easy and we add using place value.", "That you can count back and count forward.", "How to count up faster and add faster.", and "It takes a lot of practice." These findings indicate that the use of the number line increased student use of terms such as place value.

The Educreations videos not only supported and reinforced student learning but also enabled the instructor to use the videos as a formative assessment tool for assessing their process of working on three-digit addition and subtraction operations. In addition, the students' self-made videos helped the classroom instructor identify strengths and weaknesses of the students' understanding of math operations with addition and subtraction problems. This shows that technology can be incorporated seamlessly into the in a variety of ways benefiting the teacher and the students mutually.

CONCLUSION

This project showed that using the number line as an instructional strategy increased this group of second-graders' conceptual understanding of place value and their ability to solve three-digit addition and subtraction problems. Schnorr & Painter (n.d.) emphasizes the importance of bringing an authentic context to research by integrating theory with practice and expanding awareness of school/teacher needs and goals.Student use of Educreations supported the number line as an instructional strategy teaching three-digit addition and subtraction which was demonstrated in the students' verbal and visual explanations of their conceptual understanding of the number line, place value and the process of solving the given problems. The number line and Educreations together can help students develop a well-grounded foundation for their conceptual understanding of the number system, place value, addition and subtraction, and early algebra.

Action research provides a venue for teacher inquiry and improvement of instruction in small scale such as in a classroom environment. The data this classroom teacher has collected through this project is valuable to improve her teaching and student learning. In the meantime, action research as a cyclical research model opens up possibilities for greater impact in a larger context. Richard Sagor (2000) emphasizes the importance of action research in creating change in schools:

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If we are to meet the needs of a diverse population and help public education meet its moral goal of providing equal opportunity, then we need to break the tyranny of central tendency and discover an array of instructional techniques appropriate for even the smallest subpopulation of learners. To accomplish this, we need a teaching force armed with data that they can use to make the pursuit of continuous improvement a normal part of school life (p. 43).

RECOMMENDATIONS

The Educreations videos helped this new teacher as a formative assessment tool to check student learning and where the students may have difficulty solving the given problems and their use of the number line. Further research can extend this action project to higher grade classrooms following up whether the use of the number line strategy helps improve students' mathematical skills related such as multiplication, division, decimals, and fractions. An experimental study examining the use of the number line versus the number line along with Educreations videos would be helpful to see the impact of Educreations on the student learning and achievement of arithmetic tasks.

Reflecting further on this project, while the study has limitations, this exploratory collaborative action research project mutually benefited the K-12 and teacher education faculty. The classroom teacher plans to continue exploring the use of the number line and Educreations to enhance the students' learning of addition and subtraction and transfer of skills to mathematical procedures and problem-solving skills. This project showed that action research is a useful method for teachers to incorporate and explore instructional strategies as well as technology tools. Due to the developments in educational technology and particularly for new teachers, whether used as a formal research process or as a guideline, the cyclic model of action research can provide benefits for improving teaching practice.

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