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Integrated Spreadsheets as Learning Environments for Young Children

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Keywords

integrated spreadsheets, young children, numerical approach, virtual manipulatives

Cover Page Footnote

The authors are thankful to Joe McDonough, Banford Elementary School principal, Canton, NY as well as to Judy Gutekunst and Nancy Palmateer, formerly of the same school, for much needed cooperation during the project. Gratitude is extended to three anonymous reviewers for their careful review of this note enabling many insightful comments to be incorporated into the final text.

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Abstract: This classroom note shares experience of using spreadsheets with a group of 2nd grade students. The main feature of the learning environments that made effective the integration of technology and grade appropriate mathematics is the use of images of modern tools such as the Nintendo DC, the Play Station Portable, and the iPhone. The idea is illustrated by presenting a number of worksheets of so modified spreadsheets called integrated spreadsheets. The authors suggest using spreadsheets in that way offers an attractive interface for young students and enhances significantly their on-task behavior.

Key words: integrated spreadsheet, young children, numerical approach, virtual manipulatives

1 Introduction

The joint use of a spreadsheet with other tools of technology, both tactile and digital, was described earlier in [1]. In the context of partitions of integers, it was shown how manipulatives can be used to develop Ferrers-Young diagrams to be later confirmed through spreadsheet modeling. By the same token, *Maple* was used to solve difference equations motivated by spreadsheet modeling. In the present paper, the juxtaposition of a spreadsheet with other technologies is described in the context of activities carried out by the authors with 2nd grade students and described in detail elsewhere [3]. These activities were designed under the assumption that, in addition to being a powerful computational tool, an electronic spreadsheet can offer a variety of visually pleasing and cognitively engaging ways in which subject matter content and technology can be integrated. In the context of primary mathematics education, the introduction of visual materials in spreadsheets serves three main purposes. The first purpose is to provide interesting material for young students to view. The second purpose is to provide useful information related to mathematics instruction. The third purpose, in keeping with principles of universal design for learning, is to help one deliver content using a variety of means.

The notion of computer assisted signature pedagogy (CASP) was introduced by the authors in a special issue of the journal *Computers in the Schools* devoted to signature pedagogy [3]. The latter theoretical construct was developed by Shulman [13] in order to explore pedagogical commonalities among different programs of professional education, including the preparation of teachers. In the words of Shulman [13], "signature pedagogies ... are the forms of instruction that leap to mind when we first think about the preparation of members of particular professions" (p52). Any signature pedagogy consists of three attributes called structures of teaching: surface structure, deep structure, and implicit structure. Teaching at the surface structure stems from one's limited knowledge of the subject matter in question. Teaching at the deep structure is guided by one's strong confidence in the method of transmitting a body of knowledge and professional skills and abilities to learners. Implicit structure of teaching is defined by one's beliefs about subject matter and student learning. Signature pedagogy has also three descriptors: uncertainty, engagement, and formation [13]. If a teacher teaches at the deep structure level then students are allowed and even encouraged asking questions. In the case of mathematics, unexpected question may bring about an uncertainty into the classroom. Furthermore, when students are asking questions they are engaged in the learning process. Finally, it is this spirit of discussion in the classroom that forms one's professional disposition toward a subject matter, in general, and mathematics, in particular.

In the digital era, technology plays the major role in how instruction is structured, who the students are, and what is to be taught. In order for CASP to become an effective method of mathematics teaching at the primary level, decisions that one has to make regarding the choice of software are very important. For the above-mentioned project involving a group of 2nd graders, the authors have chosen an electronic spreadsheet. Designed originally for non-educational purposes, a spreadsheet was conceptualized by its inventor as a combination of an electronic blackboard and electronic chalk in a classroom [10]. Over the years, such pedagogical conceptualization proved to be quite accurate, as more and more successful classroom applications of the tool across grade levels and subject matters have been recorded at the launch of this journal [4] and continued on its pages for the past decade.

Niess [7], one of the leading authors of the Technological Pedagogical Content Knowledge framework, known as TPCK [8, 9] developed at the confluence of Shulman's [12] notion of pedagogical content knowledge and Maddux's Type I/Type II concept [5], made a similar recommendation calling for the use of spreadsheets in the primary grades. These recommendations were originally based on and then have motivated several studies dealing with the use of spreadsheets with young children as well as with their future teachers in various grade-appropriate mathematical contexts. In particular, in order to make the use of spreadsheets by young children more appealing, this paper extends earlier studies conducted at SUNY Potsdam by the first author [2] that showed promise as the application of CASP to the primary grades.

This note is aimed at teacher educators who supervise in one or other way primary teacher candidates in the field. This supervision may include providing capstone experience for the candidates in using technology with young children. Given the availability of spreadsheets (as part of *Microsoft Office*) in the schools, the authors' experience shared in this note may be of interest to those involved in teacher education programs towards helping local school partners in the appropriate use of computers at the primary level. The note may also be of interest to elementary schoolteachers looking for learning environments that integrate mathematics, technology, and context in the digital era.

2 From spreadsheets to integrated spreadsheets

In what follows, the authors' offer several teaching ideas of how one can amplify the use of a spreadsheet as a teaching and learning tool by combining it with the images of other modern technologies already familiar to young students. These may include hand held devices, such as the Nintendo DS, the PlayStation Portable, and the iPhone. In that way, while a student inputs and manipulates data through devices imbedded into a spreadsheet, the tool hides processing the data behind its amplified pedagogical image. In addition, one can create videos using a web-based type-to-text technology service *Xtranormal* (http://www.xtranormal.com/) so that students can get voice instructions from an entertaining video clip instead of reading them from the textboxes of a spreadsheet. From the point of view of CASP, the use of familiar images and tools of entertainment jointly with the computational and operational capability of a spreadsheet is important as a way of reducing anxiety and timidity frequently felt by inexperienced computer users. It is this kind of environment that the authors refer to as an integrated spreadsheet and have used in their work with 2nd grade students. Note that CASP, based on the use of integrated spreadsheets, can contribute to the improvement of invitational theory and practice [11] because their child-friendly, pleasing, and appealing features allow children to feel capable and able.

The most obvious pedagogical advantage of using an integrated spreadsheet is visually engaging and informative nature of the learning environment which offers an attractive interface for young users to be utilized in presenting information. Just as many word processing and presentation software, a spreadsheet allows for a full array of fonts, shapes, and colors. This variety not only increases students' interest in technology but it provides an effective vehicle for information delivery. In addition to controlling font, size, and color of text, one can add to a spreadsheet multiple types of shapes, outlines, colors, and backgrounds. These shapes can be edited to include text boxes displaying questions to be answered.

Additionally, a spreadsheet allows for pictures to be inserted into each worksheet as well as a background picture to be used. One role of a picture is to increase students' interest, reduce anxiety, and provide auxiliary information. Another role of a picture is to serve as a virtual manipulative. Spreadsheet-based images can be used in all the same ways as a physical manipulative, but can also be labeled, deleted, copied, resized, and re-colored. A spreadsheet offers multiple possibilities to create environments for teaching that can be tailored to individual learning styles, including those that address the need of students with disabilities. Though a teacher can design learning environments to encourage a variety of conventional reading and writing activities, spreadsheets can also be designed to emphasize non-verbal learning styles or multiple intelligences.

Using a series of worksheets, either independent or connected, allows for the creation of learning environments of different levels of technological sophistication. Students can progress through the worksheets of an Excel Workbook like through the pages of a traditional print textbook. A spreadsheet workbook can also be designed as a non-progressive educational environment so that students first choose a worksheet, which appeals to them the most, and then continue to other worksheets in any order. Furthermore, the zoom feature of a spreadsheet allows for text and pictures to be enlarged or minimized. The practical application of zooming is to adjust a spreadsheet to have all content appear on computers of varying screen resolutions. The educational application of this feature is to allow students with visual impairments or personal preferences to increase magnification of objects and information presented by a teacher.

The spreadsheets can also be combined with other technologies, including physical manipulative materials and videos. Informative and entertaining videos can be used to represent concrete elements of a mathematical problem (or any other task), deliver instructions for student actions, or introduce content in a variety of formats to accommodate different learning styles. Likewise, concrete materials can be used to support spreadsheet-based activities or provide a kinesthetic element to the learning environment. Both conventional and technological components of a lesson may be integrated with the spreadsheet to enhance teaching and learning.

3 Illustration 1: BearMath made possible by integrated spreadsheets

Consider Figure 1, the first of the series of the worksheets that comprise an environment called MathBear. The image of bear within a spreadsheet is used to capture students' interest in the activities at the very outset. The background image of forest is to make the activities as attractive as possible. Educationally, the activities begin with students' learning to type information in a textbox as they prepare for mathematical activities within a Temperature Project, similar to the one described in [2]. The textbox is used as an "answer space" where students are asked to record their responses. These responses are saved when the spreadsheet is saved, turning an interactive spreadsheet environment into an assessment tool also. All of the text boxes and cells can have their borders and internal areas filled with different colors. In Figure 2, whereas the text is black (automatic color), the background and the cells (boxes) are colored. Colored boxes are not just visually appealing but they can act as the points of reference. Indeed, instead of providing the labels "First number", "Second number", "Sum", and "Difference", the boxes can be left unlabeled and students can be asked to find the relationship among the numbers appearing in the boxes referring to them in terms of colors.

In this environment, boxes are referred to in terms of colors. One can see another use of this technique in Figure 1 where a colored X in the upper left corner of the page is used as a reference point. The colored X and other like symbols were used as a way to refer to a page and make sure that a student is on the right one. Figure 2 shows how using sliders to change the content of the cells to which sliders are attached, can help the students comprehend the notions of sum and difference through a numerical approach. The students were asked to explore and then verbally tell the authors anything they noticed about the sliders and the boxes. The answers ranged from the obvious (the sliders change numbers in boxes above them) to more insightful (the top-right box is the sum of the boxes with sliders). Usually, answers indicating the recognition of an operation had to be elicited by the authors through asking the students to discover something more about the boxes than just a change in numbers. As to the difference, the cell E10 in Figure 2 was set not to display any number if the content of cell B5 is smaller than the content of cell B10.

Note that the text "Hello! I am MathBear! What is your name?" (or any other text for that matter) could be read through the "text-to-speech" feature built into both Mac and PC's operating systems for a better appeal of the environment to young learners. Unfortunately, the computer voice is limited to somewhat robotic male of female voice, thereby diminishing the attractiveness of the environment. However, as the authors have observed, the integration of videos made possible by the use of Xtranormal service turned out to be extremely popular with the 2nd graders within the temperature project.

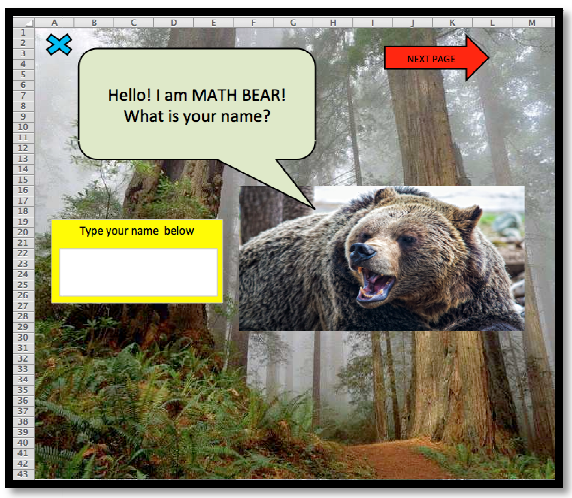

Figure 1: Learning to type in a textbox.

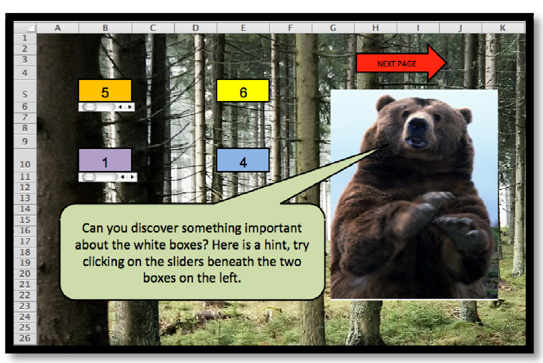

Figure 2: Recognizing arithmetic operations by playing sliders.

There are a variety of useful shapes within Microsoft Excel that may augment the use of pictures. The benefit of shapes is that one can add text. (Select object and "edit text"). The most standard use of this feature is to allow for text instructions or information to be included in the spreadsheet page. In Figure 1, a "callout" shape has been used as a dialogue bubble for the picture of bear. In Figure 2 the same feature is used to present students with a task.

The spreadsheet worksheets shown in Figures 1-4 were part of an introductory lesson to introduce 2nd graders to the basic spreadsheet features. The red arrow in the upper right of Figure 2 is a "block arrow" with fill colored in red, line colored in black with the text "Next Page" added. A hyperlink has been added to this arrow so that when a student clicks on it, she/he goes to the next worksheet in the spreadsheet.

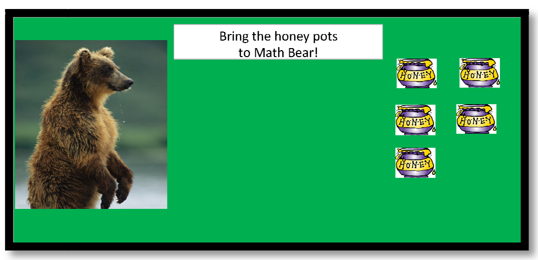

Figure 3: Honey pots as virtual manipulatives.

Figure 4: Bringing honey pots to the bear by dragging them across the page.

It should be noted that the 2nd graders have never used a spreadsheet prior to the activities and the skills of using textboxes (shaped as portable videogames), sliders and virtual manipulatives were taught as the corresponding activities were taking place. The students worked individually and were assisted by the authors as appropriate. In the course of the project, the students demonstrated a remarkable on-task behavior that the authors ascribe not only to their natural curiosity but to the entertaining context provided by integrated spreadsheets as well.

Another capability of spreadsheets is an easy accommodation of embedded pictures and objects. Pictures can be added into the page as objects, which can be resized and altered or used as background images. When using pictures as background images their "size" can be adjusted by the computers desktop resolution, not by the zoom feature. To add pictures, one can copy them from webpages and other documents and then paste into the spreadsheet. Adding objects requires going to the "Insert" tab on the ribbon and selecting either the "Picture" button in the illustrations tab.

4 Illustration 2: Integrated spreadsheets and informal mathematics

The use of virtual manipulatives (Figures 3 and 4) was in preparation for the task shown in Figure 5 – an informal (hands-on) development of the concept of average as fair sharing. In a spreadsheet environment one can draw conclusions both from an appropriately designed hands-on activity and computing. This feature is important for young children who can learn mathematical ideas and concepts before they develop formal procedural skills. Indeed, continuing in the same vein, the activity of fair sharing (Figure 5) was followed by a numeric (i.e., more formal) task of dealing with the concept of average temperature over a 5-day period. One can see in the bottom-right box of Figure 6 an answer typed by a student who recognized that the average temperature for five days would go up by one degree provided that each day sees the temperature increase by one degree. This recognition was enabled by the feature of clicking at the plus button (shown at the top of Figure 6) to open a hidden box to see the old average temperature and, building on their experience of recognizing numeric relations in Figure 2, compare the boxes with two averages (new and old). Alternatively, if each tower in Figure 5 would be one block taller, this would change their length without changing fairness in the distribution of the blocks among the towers.

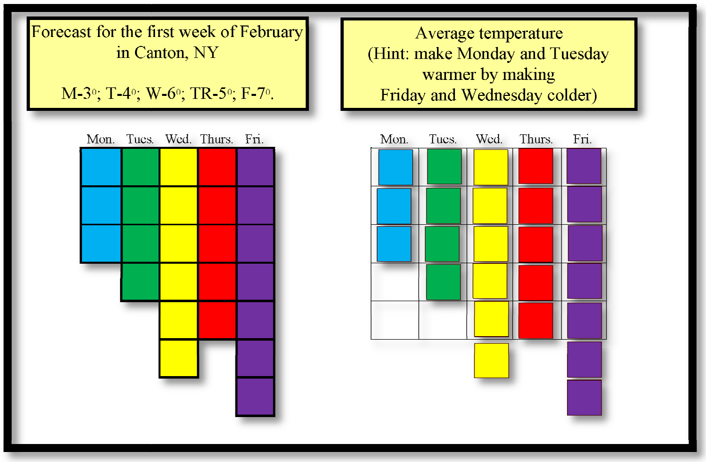

Figure 5: Understanding average as fair sharing using spreadsheet-based manipulatives.

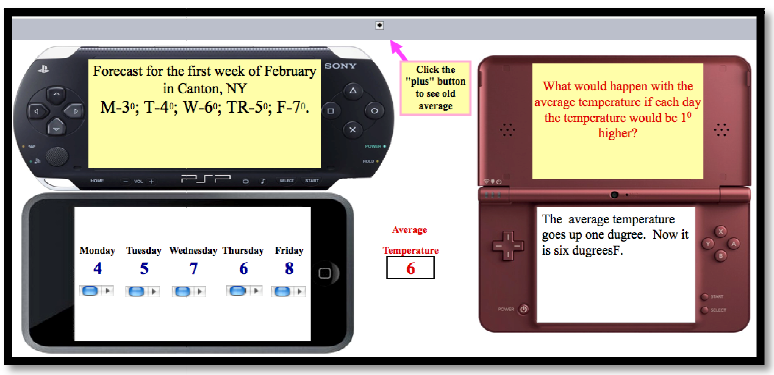

Figure 6: Mathematical problem solving using an integrated spreadsheet.

Note that in Figure 6 the authors have used an integrated spreadsheet for a variety of reasons. First, familiar handheld electronic devices helped to keep up students' interest and be engaged while working in a spreadsheet environment. Unlike the bear's image in Figures 1 and 2, these objects are not just eye-catching but serve a continuing purpose throughout the spreadsheet workbook. Whenever there is weather data, it is presented in a colored box which seems to be the "screen" for the PlayStation Portable. Likewise the mathematical component of the spreadsheet, where students may test and calculate averages looks like the screen for the IPhone. More specifically, the problems to solve are always on the colored "screen" of the Nintendo DS and the answer space for students is always in the transparent box. The calculation of average temperature by a spreadsheet was designed to display this characteristic of temperature over a five-day period approximated to a whole number in order to conform to the only number system studied in the 2nd grade mathematics curriculum.

5 Conclusion

This classroom note stemmed from the authors' experience using spreadsheets with young children. One of the teaching ideas behind the effective use of this highly sophisticated technological tool typically associated with the secondary or the tertiary levels of mathematical education, was to integrate other technological tools into a spreadsheet environment including pictures, colors, text boxes, and videos in order to increase students' interest in the activities, yet directing them towards learning the concept of average, and, most importantly, earlier than usual. In that way, the notion of an integrated spreadsheet was developed.

There are several reasons to recommend using a spreadsheet in the elementary classroom. First, the software is available in nearly every school and on many home computers. It is free to create any number of lessons using symbols and pictures that a teacher can find on the Internet (e.g., Google images). Second, a spreadsheet is easy to use. Even though one may not be as familiar with *Excel* as with *Word* and *PowerPoint*, inserting pictures, text, symbols and changing fonts is just as easy as using the two more familiar components of *Microsoft Office*. Third, sharing spreadsheets among teachers, computers, and operating systems is free and easy. Files can be saved and opened by any spreadsheet program. Finally, spreadsheets are innately mathematical tools. While many commonly available software tools are designed for visual presentation, they may lack computational capabilities. Yet spreadsheets allow for all kinds of calculations.

The authors' use of integrated spreadsheets with 2nd graders, by drawing on their familiarity with non-computational technologies, suggests the possibility that at the early grades one may "learn mathematics with understanding, actively building knowledge from experience" [6, p11]. However, the ideas about the joint use of a spreadsheet with other technologies appear to be applicable to higher levels of mathematical education. As was already mentioned in the introduction, the availability of such powerful software tools as, for example, *Maple* can augment many features of a spreadsheet in a user-friendly environment and thereby to further increase the power of technology as a medium for learning mathematics in remarkably new ways.

Acknowledgements

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