Education Tech Research Dev (2013) 61:563–580
DOI 10.1007/s11423-013-9305-6

DEVELOPMENT ARTICLE

Flipping the classroom and instructional technology integration in a college-level information systems spreadsheet course

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Published online: 11 June 2013

Abstract The purpose of this research was to explore how technology can be used to teach technological skills and to determine what benefit *flipping* the classroom might have for students taking an introductory-level college course on spreadsheets in terms of student achievement and satisfaction with the class. A pretest posttest quasi-experimental mixed methods design was utilized to determine any differences in student achievement that might be associated with the instructional approach being used. In addition, the scalability of each approach was evaluated along with students' perceptions of these approaches to determine the affect each intervention might have on a student's motivation to learn. The simulation-based instruction tested in this study was found to be an extremely scalable solution but less effective than the regular classroom and flipped classroom approaches in terms of student learning. While students did demonstrate learning gains, the process focus of the simulation's instruction and assessments frustrated students and decreased their motivation to learn. Students' attitudes towards the topic, their willingness to refer the course to others, and the likelihood that they would take another course like this were considerably lower than those of students in the flipped or regular classroom situations. The results of this study support the conclusion that a technology enhanced flipped classroom was both effective and scalable; it better facilitated learning than the simulation-based training and students found this approach to be more motivating in that it allowed for greater differentiation of instruction.

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Keywords Technology integration · Technology simulations · Computer-aided instruction · Differentiated instruction

Introduction

The primary goal of education is for students to learn. In order to maximize learning, most educators hope to personalize instruction for their students, which generally includes identifying the needs and capabilities of individual learners, making instruction relevant and meaningful, and providing flexibility in scheduling, assignments, and pacing (Keefe 2007). The goal of personalizing instruction usually means replacing traditional models of education with customized instruction. Traditional classrooms cannot always provide this type of differentiation, which has led some educators to recommend a blended learning environment (Dziuban 2004; Garrison and Kanuka 2004; Cornelius and Gordon 2008; Verkroost et al. 2008; Patterson 2012), which incorporates technology in an effort to *flip the classroom* (Bergmann and Wilie 2012; Friedman and Friedman 2001).

A simple description of flipping the classroom is to replace after-lecture homework with the expectation that students study course material prior to class (Alvarez 2011; Moravec et al. 2010). Class time is then dedicated to practice assignments, targeted remedial help, or activities designed to promote higher order thinking skills (Khan 2012). As an instructional technique, not all aspects of flipping the classroom are particularly new. For example, in some traditional classroom-based teaching approaches, teachers expect students to come to class prepared (i.e., having read assigned materials prior to class). What has recently captured the imagination of many teachers who have considered the benefits of *flipping* is the fact that advances in instructional technology have greatly enhanced our ability to make this a functional reality by increasing ubiquitous access to learning resources and thus the capacity to provide enriched resources to all students (Woolf 2010). For example, some traditional textbooks are being supplemented with internet resources, videos, and simulations. Many educators are promoting both the use of technology and some version of an inverted classroom often in a blended learning environment (Alvarez 2011; Berrett 2011; Dziuban 2004; Fulton 2012; Graham 2006; Hughes 2012; Khan 2012; Kleiman 2000; Novak 2011; Talbert 2012). However, much of the research regarding the specific pedagogical approach of *flipping the classroom* is only beginning to be published and is often based on contextually situated learning circumstances (see Lage et al. 2000; Moravec et al. 2010; Strayer 2007, 2012). Certainly, teachers need to know how to best integrate technology into the learning process because how it is used matters. Moreover, it is important to understand the challenges and what benefits are derived from each approach (Bergmann and Sams 2012; Davies 2011).

The purpose of this research was to explore how technology can be used to teach technological skills and to determine what benefit *flipping* the classroom might have for students taking an introductory-level college course on spreadsheets. We were particularly interested in how technology might be utilized to effectively promote learning in this type of course.

Literature review

Basic concept of a flipped classroom

The idea of flipping the classroom is not new (Pardo et al. 2012), but the idea has recently gained prominence due to advances in technology and increased ubiquitous access to computers and other mobile devices (Davies and West 2013). Advances in technology allow teachers to provide online instructional videos and to benefit from online assessment systems (Friedman and Friedman 2001; Woolf 2010). While many online resources are being developed (see for example Carnegie or Cengage Learning), one of the most prominent examples of online resources for *flipping the classroom* is the Khan Academy, a generously funded project that provides open educational video resources on a variety of subjects (see http://www.khanacademy.org/).

The idea of flipping the classroom with resources like the Khan Academy is simple (Khan 2012). Rather than the teacher providing synchronous in-class group instruction, students are expected to use the video resources provided, along with other materials, to learn concepts and complete tasks on their own at their own pace and at locations convenient to the student. Individual students can focus their efforts on their individual learning needs so that they are not left behind by class discussions that go too fast or become bored by class time that is spent covering content they already know.

This approach allows the teacher to use class time in different ways, such as adapting time allocation based on reports of where students need help. Students can participate in in-class discussions or receive remedial assistance on things they were not able to learn on their own. Moreover, students need attend class only if they need help beyond what is provided by the other learning resources, resulting in time savings for those who do not need in-class help.

There are a variety of ways that teachers implement a flipped classroom (Hughes 2012), but the concept is basically the same (Bergmann and Wilie 2012; Berrett 2011; Talbert 2012). Direct instruction is blended with constructivist learning pedagogies so that individualized differentiated learning is facilitated. Learning is not limited to the classroom, and students can move at their own pace and direct their efforts based on their own individual needs, thus personalizing instruction. Students are expected to take responsibility for their own learning. The teacher's role as a course designer shifts somewhat from structuring in-classroom time to providing learning resources that can be consumed asynchronously as needed.

Switching from a traditional classroom to a flipped classroom can be daunting because of the lack of accessible, effective models for accomplishing it. However, effective flipped classrooms share a few important characteristics: (1) Students transform from passive listeners to active learners, (2) technology often facilitates the endeavor, (3) class time and traditional homework time are exchanged so that homework is done first and class time takes on a fluid structure to help personalize instruction, (4) content is given context as it relates to real-world scenarios, and (5) class time is used either to help students grasp especially challenging concepts or to help students engage in higher orders of critical thinking and problem solving (Bergmann and Wilie 2012).

One of the unintended side effects of current accountability policies for teachers in the USA is that students have been released from much of the responsibility to learn (Price 2012). Flipping the classroom assumes student will take control of their learning in terms of the pace of study, mastery of content, and responsibility for coming to class prepared (Alvarez 2011; Fulton 2012).

Role of technology in flipping the classroom

As an instructional tool, technology can facilitate learning in a number of ways. Two specific areas in which technology can be extremely valuable are presenting content and assessing achievement. Because one of the instructional approaches in this study used a simulation and one of the purposes of this study was to determine the degree to which flipping the classroom might help personalize or differentiate instruction we have provided some background on these topics.

The internet and advances in streaming video have greatly improved students' access to information, as they are able to access instruction from anywhere, something that was previously relegated to the classroom. Because of these technological advances educators are also able to utilize a variety of instructional tools students can use outside the classroom including computer simulations. A simulation is a representation or model of a real-world system. Simulations are needed when working in an authentic real world setting is unsafe or impractical (Alessi 2000; Jacobs and Dempsey 1993). To make a simulation educational it is necessary for the designer to consider the instructional objectives of the instruction (Quinn 2005). The U.S. Department of Defense (1997) identified three types of simulations for a designer to consider: live simulations (i.e., real people acting out situations), virtual simulations (i.e., real people controlling avatars), and constructive simulations (i.e., people interacting within a simulated system). In addition to the type of simulation required, an instructional designer must determine the kind of fidelity required to best support the learning objectives. Fidelity refers to the degree to which the simulator accurately represents the objects and tasks in the real world. Fidelity can be applied to different aspects of the simulation. For example, deciding how realistic the physical environment needs to be is referred to as the *physical fidelity* of the simulation. *Cognitive fidelity* on the other hand refers to how realistic they tasks need to be (Jacobs and Dempsey 1993; Hays and Singer 1989; Alessi 1988, 2000). Instructional decisions should be informed by the nature of the learning outcomes (e.g., whether the learning requires the student to perform a task in a specific environment or whether they must become proficient at a cognitive task unbounded by the physical setting). If the learning objective requires the performance in a specific setting the simulator must have high physical fidelity (i.e., the situation should be very similar to the real world setting). If the learning objectives are primarily cognitive in nature it is important that the simulator has high cognitive fidelity (i.e., the type of problem the student is asked to engage in is more important than the authenticity of the physical setting in the simulation). The success of the simulation will be determined by whether it helps students accomplish the intended learning outcomes (Quinn 2005; Gatto 1993).

One way to improve learning (i.e., help student accomplish intended learning objectives) is to differentiate the instruction. The purpose of differentiation is to meet the learning needs of individual students. Personalized instruction for students generally includes identifying the capabilities of individual learners, providing flexibility in the pace and content being presented, and making instruction meaningful for the individual student (Keefe 2007). The idea of differentiated instruction is not new (Keefe and Jenkins 2002; Tomlinson 2003); however the potential for technology to facilitate differentiation is appealing (Woolf 2010). In terms of technology integrations, technology-enabled assessment can help instructors obtain diagnostic and formative information about students in order to customize instruction (Cizek 2010; Keefe 2007; Marzano 2009). This allows the instruction to be differentiated or personalized for individual students. When feedback is received on students' mastery of specific skills, students can better direct their own learning efforts. As teachers utilize technologies to automate or eliminate time-consuming tasks, they are able to more effectively differentiate the instruction.

Many factors are required for technology-enabled differentiated instruction to become a reality. Much of the educational software currently being used in schools focuses on content delivery. It does not necessarily customize instruction to the individual needs of the learner. Computer programs used in schools have primarily involved drill and practice programs for math. Improving basic word processing skills (i.e., typing) is also a prevalent technology-facilitated instructional activity taking place in schools (Ross et al. 2010). These educational software programs are intended to supplement the work of teachers rather than replacing them and are typically not integrated directly into classroom instruction. The current efforts to personalize instruction with technology have focused on managing learning (Woolf 2010).

Research purpose and questions

The purpose of this study was to examine the effectiveness and feasibility of *flipping* a college course designed to teach introductory spreadsheet skills when compared to the traditional classroom approach. The first research question was: Does the instructional approach impact learning effectiveness? Learning effectiveness was determined by students' achievement in the course. The second research question examined student's perceptions of a flipped approach relative to a traditional classroom approach. We specifically considered: (a) How much did students perceive they learned, (b) how much value did they attribute to the course, and (c) did the course impact their attitudes towards the course and the topic? The motivation for conducting this study was based on the expectation that flipping the classroom would benefit student learning.

Methods

This research used a pretest posttest quasi-experimental research design with a cross-case comparative approach to the data analysis. Descriptive and inferential statistics were used to determine the magnitude of any differences found between and within groups. Survey data supplemented assessment data to help researchers better interpret and understand the results. The setting for the study was an introductory MS Excel class taught by the Information Systems Department in the Marriott School of Management at Brigham Young University.

Description of instructional approaches

This section describes the three instructional approaches tested as treatments in this study: (1) traditional instruction in the form of large-group classroom-based lectures, (2) technology-driven independent study using MyITLab videos and software simulation, and (3) technology-enabled independent study using videos with classroom support (a flipped classroom).

Some aspects of the three treatments were similar: All three covered the same MS Excel functions and features, and all used a textbook, syllabus, assignments, and exams. Aspects of the treatments that differed are shown in Table 1. It should be noted that while there are other software programs which simulate or model MS Excel, MyITLab is the software solutions the Information Systems (ISys) Department has been using for the past several years. Its selection was one of convenience for this study but it is a well established learning management system which has been around for many years.

Table 1 Differences in treatments in this study

Treatment	Motivation & conceptual enrichment	Functions and menus	Optional remedial lectures	Focus of automated assessment	Work environment
Traditional	Provided in classroom		No	Results	MS Excel
Simulation	None	Videos		Process	Simulation
Flipped	Videos		Yes	Results	MS Excel

Form and content of instruction

In the traditional approach, instruction was provided in the classroom. In the simulated and flipped treatments, instruction was provided through videos. In the traditional and flipped treatments, additional lecture material was included to provide motivation and supply instruction for thinking logically about the Excel problems from a broader perspective: (1) In the classroom for the traditional treatment, and (2) as part of the video-based lectures in the flipped treatment. In the simulation approach, motivational materials and additional problem-solving instruction were not provided. In the flipped treatment, lectures were held that were optional to students. Those who attended had questions or wanted help.

Focus of automated assessment

In all three treatments, students were assessed through an automated grader. This grading system has been used by the ISys Department for several years as the primary assessment of student achievement in the traditional classroom sections of this course. Some tasks in Excel require the user to enter the right formula with the right parameters to get the correct outcome: Thus there was one correct way to do the work. Other tasks, like the application of formatting a range of cells, can be accomplished in multiple correct ways. The automated graders used in this study were either process based or results based. The simulated environment used a process-based approach: The automated grader gave credit only when a student used the approach prescribed by the training materials for accomplishing a task. The traditional and flipped treatments used a results-based approach by which credit was given for the right outcome even when a student used an approach different from that prescribed in the instructional materials.

Student-work environment

In the traditional and flipped treatments, students did homework and exams in the MS Excel program. In the simulated environment, MyITLab, students did homework assignments and exams in the simulated environment, being expected to learn how to perform MS Excel tasks through the simulation, not the actual software program.

Class process

In all three treatments, students were asked to read the textbook materials before attempting to complete the homework problems. In the traditional classroom treatment, the teacher provided instruction in the classroom. Students were expected to come to class, listen to the presentations, and ask questions. Then before the next class, they completed homework tasks on their own in MS Excel. In the simulation-based treatment, students did not attend class but completed their homework problems and assessments in the simulated environment. In addition to reading the textbook, students could watch videos demonstrating how to accomplish a task. In the *flipped classroom* approach, in addition to reading the textbook students could watch videos that demonstrated how to accomplish tasks. The videos also provided motivation segments and additional instruction about how to think about the problems. In the flipped classroom, students had the option to attend class to receive assistance and instruction as needed. In each situation, students' participation was voluntary. Students were free to participate to the degree they deemed necessary in order to complete the required assignments and pass the course assessments.

Participants

Subjects in this research were undergraduate students taking the introductory spreadsheet course at Brigham Young University during the winter semester of 2012, which for this course was divided into two 5-week terms. Participants in the regular classroom experience were taught during the first term; participants in the flipped classroom and simulation groups were enrolled during the second. Institutional review board procedures prohibited us from compelling students to participate in each and every aspects of the study. As a result not all students completed all the weekly surveys and course assessments. Table 2 presents participation rates, including the number of students taking the course as a required part of their program and the number who selected it as an optional course. Of the original 301 students invited to participate, 207 completed at least some elements of the data collection. Of these, 190 completed both the pretest and posttest opinion surveys; 92 completed all five of the weekly effort-tracking surveys; and 188 completed both the pretest and posttest MS Excel assessments.

Group similarities were determined based on the amount of previous training students reported. Based on this analysis it was concluded that student participants in each of the three groups had similar amounts of previous spreadsheet training, $\chi^2(6, n = 209) = 5.1$, $p = 0.531$.

Data collection and analysis

To answer the primary question regarding students' achievement, a repeated measures ANOVA was used to identify any statistically significant differences. The pretest and posttest assessments were identical tests designed to assess student realization of the learning outcomes of the course. This test was the summative assessment instructors from the regular classroom group typically gave to students upon completion of the course.

Table 2 Participation rates

Treatment type	Invited to participate	Number of respondents	Response rate (%)	Course was required	Course was optional
Regular classroom	67	65	97	49	16
Flipped classroom	61	53	87	34	19
Excel simulation	173	89	51	49	40
Total	301	207	69	132	75

Following IRB requirements, the pretest was optional for all students. The posttest assessment was required for the regular and flipped classrooms as it was a regular part of the instruction; however, the posttest was optional for the Excel simulation group, as the simulation software typically administered its own version of the final exam. Only the data from those students who voluntarily agreed to participate in the study were included.

Pretest and posttest surveys along with weekly online surveys were used to answer the question of how students perceived the experience. In addition, results from the end-of-course official course evaluations were obtained. In the post-test survey, students were asked to rate their perceptions about how much they had learned in the course, how valuable they thought the course was, whether they would recommend the course to another student, and whether they would take another Information Systems course. Differences in response distributions were compared using either an ANOVA or a non-parametric Chi squared analysis, depending on the type of data being evaluated. In weekly effort-tracking surveys, students were asked how much time they had spent on various learning activities (study time, homework time, and time getting help) and how valuable these activities had been in terms of learning the material. Survey results were disaggregated for comparison by instructional approach.

Limitations

As is the case with all research, several limitations in the design of this research exist. For example, the inability to require students to participate is an unavoidable limitation in educational research. We did however obtain a 69 % response rate, which is respectable. Still, to maintain a valid comparison, only those who completed the assessments administered for this study were used in the analysis. That is, only those who agreed to participate and completed both the pre and posttests were included.

There is also some controversy over whether it is appropriate to use parametric statistical methods with the type of data obtained from the response scale used (i.e., whether the response scale produces ordinal or interval level data). Given this concern we ran both parametric and non-parametric statistical analysis. The results were very similar (i.e., identical interpretations) so we decided to report the more powerful parametric analysis in the paper where appropriate.

Another issue facing researchers when attempting to attribute an effect to a specific intervention is that of potential confounding variables. It is possible that results obtained from this study may have been affected by any number of extraneous variables (e.g., student engagement or effort). While random assignment was impossible and we did not have direct empirical data on these factors, we did obtain self-reported information from students regarding their class attendance for those sections that held class. We also collected self-report data regarding how much time students spent studying learning materials each week. These may not be adequate measures of student effort (i.e., the amount of time students spent engaged fully in the specific learning materials) nor do they represent all the potential confounding variables. However, they do give us a basis for considering the comparability of the groups. The fact that students indicated that they spent similar amounts of time on each type of learning activity across all three treatments reduced concerns over potential confounding factors.

Another potential limitation regarding results analysis was the fact that comparison groups were of unequal sample size. Fortunately the statistical tests used are fairly robust. We also examined whether the students in both groups were heterogeneous with respect to their achievement on the pretest and found no significant difference between groups. This reduced our concerns about possible biases based on unequal sample sizes.

While we could not design around these limitations, we tested for potential bias where possible and acknowledge the fact that limitations exist. We also recognize that response patterns from this type of action research can often reveal fairly accurate indications of value and benefit (Nolen and Putten 2007).

Results

An explanatory mixed methods approach was used to explore and interpret research findings for this study. Quantitative results were used to identify patterns and themes, followed by an analysis of qualitative evidence from surveys and observations to help explain and better understand the findings.

Student achievement

A 3 × 2 mixed-design, repeated measures ANOVA was used to examine the effects of instruction type (i.e., regular classroom, flipped classroom, and Excel simulation) and time (i.e., pretest and posttest) on test scores. The assumptions of independence, normality and homogeneity were tested and found to be adequate for using this procedure. The main effects of *instruction type* were not significant, $F(2,185) = 1.5$, $p = 0.223$, indicating that scores on the pretest and posttest were statistically similar for students participating in these three modes of instruction. However, the main effect of *time* and the *time by instruction type* interaction were both significant, $F(1,185) = 731.2$, $p < 0.001$, $\eta^2 = 0.80$ and $F(2,185) = 3.53$, $p = 0.031$, $\eta^2 = 0.04$, respectively. Test scores did improve significantly from pretest to posttest for all students, but scores from the Excel simulation group did not increase to the same degree as those from students in the regular classroom and flipped classroom groups (see Fig. 1).

While pretest scores for the Excel simulation group were similar to or slightly higher than those of the regular classroom and flipped classroom groups, posttest scores for the

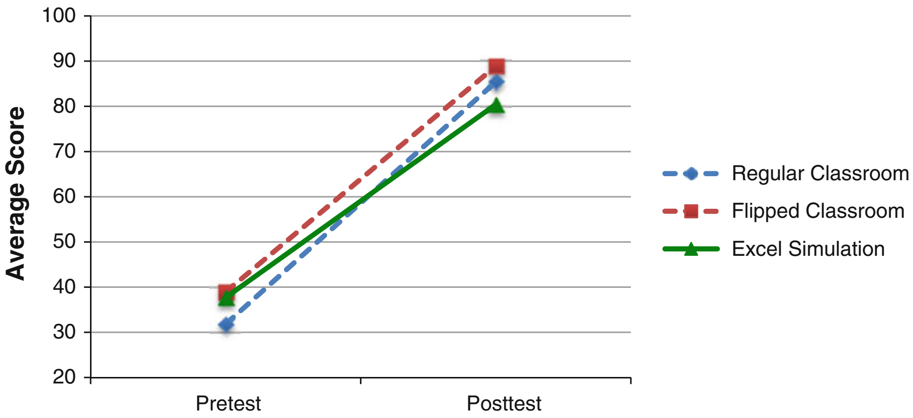

Fig. 1 Comparison of pretest and posttest results by instruction type showing a different rate of improvement for students in the MS Excel simulation group

Excel simulation group averaged 8.5 and 5 points lower than posttest scores from the flipped classroom and the regular classroom, respectively (see Table 3).

Student perceptions of the course

Table 4 shows the results of students' end-of-semester evaluation of the overall course and overall instructor. An ANOVA comparison of the three means for *overall course* was significant, $F(2{,}256) = 10.45$, $p < 0.001$. Tukey's HSD pairwise test, adjusted for unequal sample sizes, found the regular and flipped treatments were not significantly different, but both treatments were significantly higher than the simulated treatment ($p < 0.05$). The comparison of the three means for *overall instructor* was also significant, $F(2{,}256) = 19.57$, $p < 0.01$. Tukey's HSD pairwise test, adjusted for unequal sample sizes, again found the regular and flipped treatments were not significantly different, but both treatments were significantly higher than the simulated treatment ($p < 0.05$).

An analysis of students' perception of learning confirms that students using the Excel simulation approach were less likely to feel they had learned a lot from the course (see Table 5). Students in the regular and flipped classrooms responded similarly to each other regarding how much they felt they had learned. Over 80 % of the students from these

Table 3 Pretest and posttest results by instruction type

Test occasion	*n*	Mean	SD	Min. score	Max. score
Pretest					
All	188	36.1	25.0	0	100
Regular classroom	61	31.8	21.1	0	96
Flipped classroom	51	38.9	27.1	0	100
Excel simulation	76	37.7	26.2	0	100
Posttest					
All	188	84.3	17.5	17	100
Regular classroom	61	85.4	16.1	27	99
Flipped classroom	51	88.9	15.3	17	100
Excel simulation	76	80.4	19.2	28	100

Table 4 Results from students' end-of semester course evaluations by instruction type

	n	Mean	SD
Overall course			
Regular classroom	35	6.8	1.0
Flipped classroom	37	7.0	0.9
Excel simulation	198	6.1	1.4
Overall instructor			
Regular classroom	35	7.2	0.9
Flipped classroom	37	7.4	0.9
Excel simulation	198	6.3	1.3

Responses based on an 8-point scale, with 1 as *extremely poor* and 8 as *outstanding*

Table 5 Posttest results for the question "I learned a lot taking this course"

Response options	Regular classroom $n = 59$	Flipped classroom $n = 54$	Excel simulation $n = 77$	Total $n = 190$
Very strongly agree	29 (49 %)	30 (56 %)	18 (23 %)	77 (41 %)
Strongly agree	21 (36 %)	15 (28 %)	31 (40 %)	67 (35 %)
Agree	7 (12 %)	6 (11 %)	17 (22 %)	30 (16 %)
Somewhat agree	2 (3 %)	2 (4 %)	9 (12 %)	13 (7 %)
Somewhat disagree	0 (0 %)	1 (2 %)	0 (0 %)	1 (1 %)
Disagree	0 (0 %)	0 (0 %)	2 (3 %)	2 (1 %)
Strongly disagree	0 (0 %)	0 (0 %)	0 (0 %)	0 (0 %)
Very strongly disagree	0 (0 %)	0 (0 %)	0 (0 %)	0 (0 %)

Response distributions were significantly different by group, $\chi^2(10, n = 190) = 24.2, p = 0.007$

classes marked *strongly agree* or *very strongly agree* to indicate that they had learned a lot, compared to only 63 % from the Excel simulation group who indicated these responses.

Student responses to this question were consistent with the results from the end-of-semester course evaluations collected for these courses by the university. In response to the question "How much did you learn from this course?" the mean was 6.9 for both flipped and regular treatments and was 6.1 for the simulation treatment (on a scale on which 1 represents *extremely little* and 8 indicates a *great deal*). An ANOVA comparison of the three means was significant, $F(2,256) = 8.77$, $p < 0.001$. Tukey's HSD pairwise test, adjusted for unequal sample sizes, found that the regular and flipped treatments were not significantly different, but both were significantly higher than the simulated treatment ($p < 0.05$).

Based on results from the posttest survey for this study, students in the regular and flipped classrooms were much more likely to feel the class was extremely valuable compared with students in the Excel simulation class (see Table 6).

Students in the regular and flipped classrooms were much more likely to indicate a willingness to recommend this course to another student compared with students in the Excel simulation class (see Table 7).

Students in the flipped classroom were much more likely to indicate a willingness to take another Information Systems course than were students in both the regular and simulation-based classes (see Table 8).

Table 6 Posttest results for the question "How valuable was this course?"

Response options	Regular classroom $n = 58$	Flipped classroom $n = 54$	Excel simulation $n = 75$	Total $n = 187$
Extremely valuable	26 (45 %)	29 (53 %)	16 (21 %)	71 (38 %)
Valuable	31 (53 %)	16 (30 %)	43 (57 %)	90 (48 %)
Somewhat valuable	1 (2 %)	8 (15 %)	13 (17 %)	22 (12 %)
Somewhat waste of time	0 (0 %)	0 (0 %)	3 (4 %)	3 (2 %)
Waste of time	0 (0 %)	1 (2 %)	0 (0 %)	1 (1 %)
Extreme waste of time	0 (0 %)	0 (0 %)	0 (0 %)	0 (0 %)

Response distributions were significantly different by group, $\chi^2(8, n = 187) = 29.5, p < 0.001$

Table 7 Posttest results for the question "Would you recommend this course to another student?"

Response options	Regular classroom $n = 58$	Flipped classroom $n = 54$	Excel simulation $n = 75$	Total $n = 187$
Absolutely yes	36 (62 %)	36 (67 %)	23 (31 %)	95 (51 %)
Probably	20 (35 %)	13 (24 %)	33 (44 %)	66 (35 %)
Somewhat likely	1 (2 %)	5 (9 %)	14 (14 %)	20 (11 %)
Somewhat unlikely	1 (2 %)	0 (0 %)	2 (3 %)	3 (2 %)
Unlikely	0 (0 %)	0 (0 %)	2 (3 %)	2 (1 %)
Extremely unlikely	0 (0 %)	0 (0 %)	1 (1 %)	1 (1 %)

Response distributions were significantly different by group, $\chi^2(10, n = 187) = 28.5$, $p = 0.002$

Table 8 Posttest results for the question "Would you take another ISys course?"

Response options	Regular classroom $n = 58$	Flipped classroom $n = 54$	Excel simulation $n = 75$	Total $n = 187$
Absolutely yes	16 (28 %)	24 (44 %)	15 (20 %)	55 (29 %)
Probably	24 (41 %)	19 (35 %)	26 (35 %)	69 (37 %)
Somewhat likely	11 (19 %)	6 (11 %)	19 (25 %)	36 (19 %)
Somewhat unlikely	4 (7 %)	5 (9 %)	5 (7 %)	14 (8 %)
Unlikely	2 (3 %)	0 (0 %)	7 (9 %)	9 (5 %)
Extremely unlikely	1 (2 %)	0 (0 %)	3 (4 %)	4 (2 %)

Response distributions were significantly different by group, $\chi^2(10, n = 187) = 19.0$, $p = 0.041$

Table 9 Average weekly response for the question "How much time in hours did you spend on learning activities this week?"

Learning activity	Regular classroom Hours (SD)	Flipped classroom Hours (SD)	Excel simulation Hours (SD)	Total Hours (SD)
Study	1.1 (0.72) $n = 55$	1.1 (0.60) $n = 49$	1.0 (0.67) $n = 85$	1.1 (0.65) $n = 189$
Homework	1.3 (1.3) $n = 63$	1.1 (0.65) $n = 39$	0.7 (0.67) $n = 54$	1.1 (0.98) $n = 156$
Getting help	0.4 (0.55) $n = 23$	0.4 (0.46) $n = 20$	0.7 (0.45) $n = 25$	0.5 (0.50) $n = 68$
Total	2.5 (1.5) $n = 63$	2.3 (1.2) $n = 52$	2.2 (1.4) $n = 90$	2.3 (0.69) $n = 205$

Total reported time spent on course was not significantly different by group, $F(2,202) = 1.39$, $p = 0.252$. Only those students who reported participating in these activities were included in this analysis

Time spent on course learning activities

Table 9 presents response data on the question of how much time students spent on the various learning activities in the course. There were no significant differences in the amount of time spent on the course overall. Students from the Excel simulation group did, however, report spending less time on homework, $F(2,153) = 6.4$, $p = 0.002$, than those in the regular and flipped classrooms. This might be explained by the fact that the simulated course instruction and homework were essentially the same learning activity.

These results include only those students who reported spending some time on these activities. Of interest is the fact that few students reported getting outside help. And when they did seek help, they tended to spend only about half an hour per week getting help. Those students in the Excel simulation group who reported getting help tended to spend slightly more time on the activity. But based on evidence from students' contact with instructors, these students were often concerned that the simulation failed to give them credit for a correct solution to a problem that did not follow the prescribed process delineated by the system.

Value of course learning activities

Table 10 presents students' perceptions of the value of the various learning activities in which they participated. Reponses were reported weekly and averaged for each student. The response scale ranged from 1, *extremely unhelpful* (or an extreme waste of time), to 6, *extremely valuable*. An analysis of the data was done for each of the specific learning activities (i.e., study, required homework tasks, and help received). All of the results were statistically significant. In all cases, an analysis of the data showed that students in the Excel simulation group consistently reported a lower value for the learning activities than students in the regular and flipped classrooms. In fact, few students in the Excel simulation group indicated they felt the learning activities required in the course were extremely valuable (i.e., less than 10 %), contrasting with about 30 % in the regular and flipped classrooms.

Results from the end-of-semester course evaluations were consistent with these results: In the course evaluations students rated the effectiveness of course materials and activities higher in the regular and flipped treatments than in the simulation treatment. In response to the request "Rate the effectiveness of the course materials and learning activities," the mean was 7.0 for the flipped treatment and 6.9 for the regular treatment; the simulation treatment group rated the course materials and learning activities at 6.0 (where 1 represents *extremely ineffective* and 8 indicates *extremely effective*). An ANOVA comparison of the three means was again significant, $F(2,256) = 12.49$, $p < 0.001$. Tukey's HSD pairwise test, adjusted for unequal sample sizes, found that the regular and flipped treatments were not significantly different, but that both of these treatments were significantly higher than the simulated treatment ($p < 0.01$).

On the end-of-semester course evaluations, students in the regular and flipped treatments also rated the intellectual skills they developed in the course higher than did students in the simulation treatment. In response to the request "Rate the course on how effective it was in terms of helping you develop intellectual skills," the mean was 6.9 for the flipped

Table 10 Average Weekly Results for the Question "How Valuable Were These Learning Activities?"

Learning activity	Regular classroom Mean (SD)	Flipped classroom Mean (SD)	Excel simulation Mean (SD)	Total Mean (SD)
Study	4.2 (0.67) $n = 57$	4.2 (0.58) $n = 50$	3.7 (0.67) $n = 87$	4.0 (0.69) $n = 194$
Homework	4.3 (0.51) $n = 63$	4.2 (0.76) $n = 51$	3.8 (0.77) $i = 89$	4.1 (0.74) $n = 203$
Getting help	4.2 (0.64) $n = 35$	4.0 (0.84) $n = 24$	3.5 (0.71) $n = 39$	3.9 (0.79) $n = 98$

Only those students who reported participating in these activities were included in this analysis treatment and 6.5 for the regular treatment; however, students in the simulation treatment group gave an average rating of only 5.8. An ANOVA comparison of the three means was significant, $F(2{,}256) = 11.08, p < 0.001$. Tukey's HSD pairwise test, adjusted for unequal sample sizes, found that the regular and flipped treatments were not significantly different, but that both of these treatments were significantly higher than the simulated treatment ($p < 0.01$).

Discussion and conclusions

This research explored how technology can be used to teach technological skills and what benefit flipping the classroom might have for students taking a college course for introductory level spreadsheets. The criteria for evaluating these instructional approaches included both academic achievement data and student perception data regarding the value of various learning experiences provided.

Comparing the regular, flipped, and simulation-based courses demonstrated that how technology is integrated into a course makes a difference. While somewhat less time consuming (i.e., students spent less time doing homework), using the Excel simulation software to teach spreadsheet skills was not as effective as other methods of instruction tested in this study. This should not be seen as a condemnation of all simulation software as students did learn using this approach. However, students using the software simulation approach did not learn as much as students instructed with the actual software program. Students considered the instructional activities less valuable. They also indicated they would be less likely to take another Information Systems class or to recommend this course to a fellow student.

These results support recommendations made by Davies and West (2013) as well as Koehler and Mishra (2008) that the U.S. Department of Education's (2010) expectation that technology should be used in schools must be regulated by an expectation that it be used in a instructionally sound manner (i.e., one that takes into consideration the intended learning and the contextual factors that might affect learning). Instructors may choose to use technology for various reasons. One reason often cited for using technology in delivering introductory Excel classes is implementation efficiencies. As an introductory Excel class is often a general requirement for all students, a scalable teaching approach is needed. To deliver this course in a traditional classroom environment would be somewhat impractical because of the number of faculty and classroom computers needed. If the objective of the learning method is instructional efficiency and scalability, then the flipped and simulation-based course models can be considered. Both offer alternatives that can be implemented with few faculty and technology resources. In this regard the simulation-based method has a slight advantage over the flipped model because using it does not require the institution to install the Excel software on university computers; the instruction and assessment can be conducted through an internet-based simulation.

Despite the implementation advantages of the simulation-based approach, this study found it not as effective as either the flipped or regular approaches in terms of student learning, student perceptions of the learning process, and student attitudes toward the course. This appears to result at least in part from limitations in using a simulation of an existing software application. In many ways the simulation was not rich enough to provide students with the same experience as the actual software, despite the fact that this particular software is commercially published and recognized as the most sophisticated Excel simulation software available. In particular, the simulation was not complex enough to allow for multiple ways to achieve a correct result. This was a particular deficiency given the difficult nature of the tasks students completed as part of the assigned work in the class. Had more trivial tasks been assigned, this issue would not likely have been as important because fewer paths would have lead to the correct result. In this study we found that the use of a simulated environment (i.e., technology simulating the actual software application) was less effective and less satisfying for the learners.

Compared to the simulated treatment, the flipped classroom approach provided a method for delivering the class that was both scalable and effective. The flipped classroom approach allowed students to learn course content at their own pace, and students were not required to come to class unless they needed help beyond the asynchronous materials, allowing them to make better use of their time and improving their perception of the class. Class time was more effective because it was used to provide remedial assistance to the few students who needed extra help. Another efficiency in terms of the implementation of this approach was the scalability of the course: A flipped classroom of this type can easily accommodate a larger number of students in each section of the course. Based on course assessments, this approach was also more effective. Students not only made greater academic gains but were also more satisfied with the learning environment. Moreover, students completed their work in the MS Excel environment, so the limitations associated with the simulation environment were not present.

The flipped approach was also better than the regular approach for delivering this course but not significantly. This finding was somewhat surprising. We expected to find that the flipped approach would be more scalable than the regular approach for this class and hoped that the flipped approach would be as effective in terms of student learning and attitudes about the class materials. We found no statistical differences between the flipped and regular approaches for student evaluations of the course and instructor, student reports on how much they learned in the class, student assessments of the value of the class, students' reported willingness to recommend the course to another student, and student evaluations of the learning activities in the class. However, in each area the mean scores for the flipped approach were slightly more favorable than those of the regular approach. We also found that students were significantly more willing to take another Information Systems class and that student learning in the flipped class was higher than in the regular class. The evidence suggests that the flipped approach is at least as effective as the regular approach for delivering this class and somewhat more scalable.

One reason that the flipped approach may be better than the regular approach relates to a dilemma regular classroom instructors face when delivering this type of content. Our experience suggests that students enter an introductory Excel class with a wide range of technological backgrounds, and instructors face a dilemma in pacing the classroom instruction. Pacing that is too fast may cause those with limited technological backgrounds to fall behind and perform poorly. But pacing that is too slow may result in those with moderate to extensive technological backgrounds finding lower satisfaction with the learning process. Instructors typically choose a pace that is too slow for some and too fast for others—a suboptimal pace for many if not nearly all students. The flipped approach allows students to pace themselves through the subject material within the context of the due dates. Those with extensive technological backgrounds can move more quickly through the materials than those with limited backgrounds.

We also expected to find that the flipped approach might be inferior to the regular approach in motivating students to recognize the importance of the class materials. We thought that the ability of good instructors to communicate the importance of the subject matter and provide effective conceptual frameworks to help students organize and contextualize the educational experience would be difficult to reproduce in the flipped approach. But the results of this study seem to suggest that this is not the case. The course materials, particularly the set of instructional videos, created for the flipped approach, were as effective at motivating students about the subject matter as the instructors delivering the regular approach.

In summary, our findings suggest that the flipped approach and simulation-based approach were both more instructionally efficient and scalable than the regular classroom approach for the Excel course studied. The cost to achieve this scalability, however, would require greater upfront investment in the development of the video resources or simulation software. Although more scalable, the simulation-based approach was somewhat inferior to the other two instructional approaches in terms of student learning effectiveness.

In addition, these findings lead us to believe that the use of technology to simulate a specific software application like Excel has several other disadvantages for developing skills. While students did demonstrate learning gains, the process focus of the simulation (i.e., assessing students' ability to follow a specific process in order to complete tasks) was frustrating for students and decreased their motivation to learn. Students' attitudes towards the topic, their willingness to refer the course to others, and the likelihood that they would take another course like this were considerably lower than those of students in the flipped or regular classroom situations.

Limitations and future research

While our study provides compelling evidence of the efficacy of the flipped approach over both the regular and simulation-based approaches, caution should be used in generalizing the findings beyond the scope of the context of our study. The class used for this study was a short (5-week), well structured course that teaches students basic and intermediate skills with a software application. Student performance on class activities can be precisely defined, and the assessment of learning objectives has been automated. These circumstances enable the efficiencies gained by the flipped and simulation-based approaches over the regular approach. Instruction in other contexts may not be as amenable to the flipped or simulation-based approaches. Future research in this area is required.

References

Alessi, S. M. (1988). Fidelity in the design of instructional simulations. *Journal of Computer-Based Instruction, 15*(2), 40–47.

Alessi, S. M. (2000). Simulation design for training and assessment. In H. F. O'Neil & D. H. Andrews (Eds.), *Aircrew training and assessment* (pp. 199–224). Mahwah: Lawerance Erlbaum Associates.

Alvarez, B. (2011). Flipping the classroom: Homework in class, lessons at home. *Learning First*. Retrieved 4 June 2013 from http://www.learningfirst.org/flipping-classroom-homework-class-lessons-home.

Bergmann, J., Overmyer, J., & Wilie, B. (2012). The flipped class: Myths versus reality. *The Daily Riff.* Retrieved 4 June 2013 from http://www.thedailyriff.com/articles/the-flipped-class-conversation-689.php.

Bergmann, J., & Sams, A. (2012). Before you flip, consider this. *Phi Delta Kappan, 94*(2), 25.

Berrett, D. (2011). How 'Flipping' the classroom can improve the traditional lecture. *The chronicle of higher education.* Retrieved 4 June 2013 from http://chronicle.com/article/How-Flipping-the-Classroom/130857/.

Cizek, G. J. (2010). An introduction to formative assessment: History, characteristics, and challenges. In G. J. Cizek & H. L. Andrade (Eds.), *Handbook of formative assessment* (pp. 3–17). New York: Routledge.

Cornelius, S., & Gordon, C. (2008). Providing a flexible, learner-centered programme: Challenges for educators. *Internet and Higher Education, 11*, 33–41.

Davies, R. (2011). Understanding technology literacy: A framework for evaluating educational technology integration. *TechTrends, 55*(5), 45–52. doi:10.1007/s11528-011-0527-3.
Davies, R., & West, R. (2013). Technology integration in school settings. In M. Spector, D. Merrill, J. Elen, & M. J. Bishop (Eds.), *Handbook of research on educational communications and technology* (4th ed.). New York: Taylor & Francis Ltd.
Dziuban, C. D. (2004). Blended learning. In C. O. Boulder (Ed.), *Educause center for applied research*. Retrieved 4 June 2013 from http://net.educause.edu/ir/library/pdf/ERB0407.pdf.
Friedman, H., & Friedman, L. (2001). Crises in education: Online learning as a solution. *Creative Education, 2*(3), 156–163.
Fulton, K. P. (2012). 10 reasons to flip. *Phi Delta Kappan, 94*(2), 20–24.
Garrison, D. R., & Kanuka, H. (2004). Blended learning: Uncovering its transformative potential in higher education. *Internet and Higher Education, 7*(2), 95–105.
Gatto, D. (1993). The use of interactive computer simulations in training. *Australian Journal of Educational Technology, 9*(2), 144–156.
Graham, C. R. (2006). Blended learning systems: Definition, current trends, and future directions. In C. J. Bonk & C. R. Graham (Eds.), *Handbook of blended learning: Global perspectives, local designs*. San Francisco: Pfeiffer Publishing.
Hays, R. T., & Singer, M. J. (1989). *Simulation fidelity in training system design: Bridging the gap between reality and training*. New York: Springer-Verlag.
Hughes, H. (2012). Introduction to flipping the college classroom. In T. Amiel & B. Wilson (Eds.), *Proceedings from world conference on educational multimedia, hypermedia and telecommunications 2012* (pp. 2434–2438). Chesapeake: AACE.
Jacobs, J. W., & Dempsey, J. V. (1993). Simulation and gaming: Fidelity, feedback, and motivation. In J. V. Dempsey & G. C. Sales (Eds.), *Interactive instruction and feedback* (pp. 197–227). Englewood Cliffs: Educational Technology Publications.
Keefe, J. (2007). What is personalization? *Phi Delta Kappan, 89*(3), 217–223.
Keefe, J., & Jenkins, J. (2002). Personalized instruction. *Phi Delta Kappan, 83*(6), 440–448.
Khan, S. (2012). *The one world schoolhouse: Education reimagined*. London: Hodder and Stoughton.
Kleiman, G. M. (2000). Myths and realities about technology in K-12 schools. In the harvard education letter report. *The digital classroom: How technology is changing the way we teach and learn*. Retrieved 4 June 2013 from http://www.edletter.org/dc/kleiman.htm.
Koehler, M. J., & Mishra, P. (2008). Introducing TPCK. In AACTE Committee on Innovation and Technology (Ed.), *The handbook of technological pedagogical content knowledge (TPCK) for educators*. New York: American Association of Colleges of Teacher Education and Routledge.
Lage, M. J., Platt, G. J., & Treglia, M. (2000). Inverting the classroom: a gateway to creating an inclusive learning environment. *Journal of Economic Education, 31*(1), 30–43.
Marzano, R. J. (2009). Formative versus summative assessments as measures of student learning. In T. J. Kowalski & T. J. Lasley (Eds.), *Handbook of data-based decision making in education* (pp. 261–271). New York: Routledge.
Moravec, M., Williams, A., Aguilar-Roca, N., & O'Dowd, D. K. (2010). Learn before lecture: a strategy that improves learning outcomes in a large introductory biology class. *CBE Life Sciences Education, 9*, 473–481.
Nolen, A. L., & Putten, J. V. (2007). Action research in education: Addressing gaps in ethical principles and practices. *Educational Researcher, 36*(7), 401–407. doi:10.3102/0013189X07309629.
Novak, G. M. (2011). Just-in-time teaching. *New Directions for Teaching and Learning, 2011*(128), 63–73. doi:10.1002/tl.469.
Pardo, A., Pérez-Sanagustin, M., Hugo, A., Parada, H. A., & Leony, D. (2012). Flip with care. *Proceedings of SoLAR southern flare conference*. Retrieved 4 June 2013 from http://www.researchgate.net/publication/232906379_Flip_with_care.
Patterson, G. A. (2012). An interview with Michael Horn: Blending education for high-octane motivation. *Phi Delta Kappan, 94*(2), 14–18.
Price, J. (2012). *Textbook bling: An evaluation of textbook quality and usability in open educational resources versus traditionally published textbooks (Unpublished master's project)*. Provo: Brigham Young University.
Quinn, C. N. (2005). *Engaging learning: Designing e-learning simulation games*. San Francisco: Pfeiffer Publishing.
Ross, S. M., Morrison, G., & Lowther, D. L. (2010). Educational technology research past and present: Balancing rigor and relevance to impact school learning. *Contemporary Educational Technology, 1*(1), 17–35.

Strayer, J. F. (2007). *The effect of the classroom flip on the learning environment: A comparison of learning activity in a traditional classroom and a flip classroom that used an intelligent tutoring system (Unpublished doctoral dissertation)*. Columbus: Ohio State University.

Strayer, J. F. (2012). How learning in an inverted classroom influences cooperation, innovation and task orientation. *Learning Environments Research, 15*(2), 171–193.

Talbert, R. (2012). Inverted classroom. *Colleagues, 9*(1), Article 7.

Tomlinson, C. (2003). *Fulfilling the promise of the differentiated classroom: Strategies and tools for responsive teaching*. Alexandria, VA: Association for Supervision and Curriculum Development.

U.S. Department of Defense. (1997). *DoD modeling and simulation (M&S) glossary, DoD 5000.59-M*. Retrieved 4 June 2013 from http://www.dtic.mil/whs/directives/corres/pdf/500059m.pdf.

U.S. Department of Education. (2010). *Transforming American education: Learning powered by technology. National education technology plan 2010*. Washington, DC: Office of Educational Technology.

Verkroost, M., Meijerink, L., Lintsen, H., & Veen, W. (2008). Finding a balance in dimensions of blended learning. *International Journal on E-Learning, 7*(3), 499–522.

Woolf, B. P. (2010). *A roadmap for education technology*. Retrieved 4 June 2013 from http://www.coe.uga.edu/itt/files/2010/12/educ-tech-roadmap-nsf.pdf.

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