Introductory Information Systems Course: Driving 21st Century Skill Development with Student Response Systems

Completed Research

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Abstract

To be competitive in our global economy, Information Systems (IS) graduates are expected to have mastered content as well as have developed people-related or 21st century soft-skills such as teamwork, effective communication, and cross-cultural interactions. The challenge is the infusion of soft-skill development into the curriculum in a manner that enhances the classroom learning experience. Arguably, the sooner the better. This paper reports on research conducted to examine ways in which to instill both 21st century and domain-specific knowledge. We examined the effectiveness of using student response systems to facilitate content based collaborative learning and examined whether participation in heterogeneous groups can lead to the strengthening of soft-skill development and content knowledge. Results from the study revealed that the use of sound pedagogy coupled with good instructional design strategies can be used to engage students in intense and purposeful interactions, which led to stronger individual and group academic performance.

Keywords

Interpersonal skills development; student response system; effective learning environment; collaborative learning, group learning.

Introduction

Freshman introductory courses can be a challenge to teach at most colleges and universities (Hornsby & Osman, 2014; Kivunja, 2015; Lynch & Pappas, 2017). This is due to several significant and interrelated factors. These are class sizes, the amount of materials to be covered, and the overall lack of engagement of students in the course. A simple and well-used teaching practice to overcome these challenges is to ground the lectures, learning activities, and assessment efforts on domain specific knowledge acquisition, which allows the primary contents of a given course to be covered properly (Cattel, 1987; Evans, 2003). However, a major issue with an approach that focuses on domain knowledge is keeping students involved in the course, beyond the memorizing facts, figures, and definitions for an eventual exam (Entwistle, 1988). Further, research shows that students’ active engagement and participation in the learning process will often lead to deeper thinking, problem solving, and stronger orientation to peer collaborations (Deslauriers, Schelew, & Wieman, 2011; Michaelsen, Knight, & Fink, 2002). Moreover, given the manifest requirements of the 21st century employment landscape, it is important and critical for students to be exposed to other viewpoints and differing perspectives while in school (Bialik, & Fadel, 2015). Through the inclusion of active learning and teamwork approaches in classroom activities, faculty can help students develop or strengthen their ability to communicate, solve problems and build alliances while working in heterogeneous groups. These issues have provided the motivation to explore how the integration and use of a student response system (SRS) can help facilitate interpersonal skills development and domain specific knowledge acquisition by students in a peer instructional environment.
We developed this research to address the challenge of engaging students in an introductory information systems course in a manner that starts students down the path of soft-skill development and increases content mastery. To this end, we incorporated a student response system (a.k.a., clickers) to create an interactive group learning instructional experience. The research questions that helped motivate this work include: What are student perceptions of an SRS driven group learning environment? How do students perceive diverse group engagement in relation to communication, collaboration, and learning? Can individual performance improve following group discussions as facilitated by a student response system?

**Background**

One of the goals of this work is to better understand how a student response system can be used to facilitate the development of 21st century skills and content knowledge. More specifically, do students perceive SRSs as beneficial and how can the student response system be used to engage the students in a learning experience that advances their content knowledge and teamwork abilities. To this end, our research was motivated by Chickering & Gamson’s seven principles of good practice, diffusion of innovation theory, and the social interdependence theory (1991).

**Twenty-First Century Skills**

As students migrate toward graduation it is important that they develop 21st century skills if they are to be competitive in our global economy. While the list of these skills will vary depending on the source (Griffin, McGaw, & Care, 2012; National Education Association, 2012; Trilling, Bernie, & Fadel, 2009), they can be categorized as content knowledge, information, media, and technology skills, learning and innovation skills, and life and career skills (P21, 2019). The challenge for many Information Systems (IS) programs is the integration of two of these categories (learning and innovation skills, and career and life skills) into the curriculum. The areas of content knowledge, information, media, and technology typically do not pose a challenge as they are a primary component of IS programs.

The learning and innovation 21st century skill set can be defined by the 4Cs - critical thinking, creativity and innovation, communication, and collaboration. Critical thinking involves the ability to reason effectively, use systems thinking, make judgements and decisions and solve problems (Halpern, 1999; Marsh, 2012). Creativity and innovation include the ability to draw from a plethora of idea creation techniques during the formulation of new and worthwhile ideas (Willingham, 2007). Communication addresses the ability to effectively listen for meaning, articulate thoughts and ideas (e.g., oral, written, nonverbal) for multiple purposes (e.g., teach, motivate) in diverse environments (Bennett & Salonen, 2007; Bloom and River Path Associates 2000). Collaboration refers to the ability to work with diverse teams while being flexible, responsible, and respectful during the goal accomplishing process (P21, 2019).

The career and life 21st century skill set consist of flexibility and adaptability, initiative and self-direction, social and cross-cultural interaction, productivity and accountability, and leadership and accountability (Matveev & Milter, 2004; Miri, David, & Uri, 2007). While incorporating opportunities to develop all forms of 21st century skills into a single course is not necessarily probable, it is possible to include key elements of this list into an introductory course.

When taking on the challenges of an introductory IS course it is important to consider and implement the elements needed to create an effective learning environment. Many of these elements can be incorporated by following Chickering & Gamson’s principles for good practice in undergraduate education which include the use of active learning techniques, the development of reciprocity and cooperation among students (collaborative learning), and the provision of prompt feedback (Chickering & Gamson, 1991). Each of these can be used as a conduit for enhancing both classroom knowledge and 21st century skills.

**Student Response Systems**

An SRS’s main function is to serve as a polling resource and is made up of software and hardware components. The hardware consists of wireless response pads and a receiver that is connected to a computer. The software provides the means to create the questions which can then be projected during a polling session such as a multiple-choice quiz. Student responses are collected by the hardware, processed
by the software, and then projected to the class as controlled by the instructor. While this is a typical SRS setup, there exist variants such as a smartphones and web technologies.

A key SRS classroom advantage is the facilitation of sharing and discussion among students (Hall, Collier, Thomas, & Hilgers, 2005; Lantz, 2010). Thus, an SRS can be leveraged to foster knowledge sharing in diverse and cross-cultural groups. Consequently, such an approach will allow instructors to create learning experiences that meet both academic goals and employers’ expectations of 21st century college graduates. While much SRS research is focused on achievement, we draw from diffusion of innovation theory (Rogers, 1995) to argue that the perceived innovativeness of group learning driven by an SRS influences group learning effectiveness.

**Research Model**

In this study, we are motivated by the identification of an effective teaching and learning model that starts students down the path of learning 21st century interpersonal skills and the active learning of course content. We propose that positive perceptions of a student response system can promote active learning and engagement amongst diverse groups which promotes 21st century interpersonal skills development opportunities and results in increased learning performance.

**Related Hypothesis**

We believe that positive students' perception of an SRS can have a significant impact on group interaction during classroom-based activities and learning, resulting in the acquisition of 21st century interpersonal skill and increased performance. To this end, we hypothesize:

H1 – Students perceive the SRS as a positive resource for group leaning.

H2 – Students perceive diverse group engagement as a positive influence on communication, collaboration, and learning.

H3 – SRS driven group discussions significantly improve mastery of course content or domain knowledge.

**Methodology**

We conducted this research in four sections of a freshman computing course taught by one of the researchers over the course of two semesters at a small south-eastern public university with an enrollment of 6,000 students and a college enrollment of 900 students. In total, 131 students agreed to participate with three sections having over 35 students and the fourth had 22 students (Table 1). We used a mixed method design, manipulating exposure to group collaboration on selected topics within the classroom. We used surveys to collect student perceptions on the SRS, group dynamics, personal contributions, and satisfaction. Objective measures for learning are based on quiz and midterm performance. Details of our design, measures, and student participants are to follow.

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>Groups</th>
<th>Group Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section A</td>
<td>35</td>
<td>8</td>
<td>3-5</td>
</tr>
<tr>
<td>Section B</td>
<td>38</td>
<td>8</td>
<td>3-6</td>
</tr>
<tr>
<td>Section C</td>
<td>36</td>
<td>8</td>
<td>3-5</td>
</tr>
<tr>
<td>Section D</td>
<td>22</td>
<td>6</td>
<td>3-4</td>
</tr>
</tbody>
</table>

**Table 1. Overall Participation**
Course Background

The course we used for this research was Introduction to Computers and Information Processing. This course meets weekly and introduces general computer and information systems concepts such as the history of computing, hardware, software, ethics, security, and programming. Enrolled students represent a diverse campus as nine of the forty-two degrees require the course. The colleges that offer the degrees include: Arts & Sciences, Business Administration, Education, and Visual and Performing Arts.

Implementation Procedures

We conducted each class using an approach that would allow us to examine the perceptions and effects of an SRS in a group learning environment. At the beginning of the semester, we randomly assigned students into small groups (3-6) for the duration of the course. We chose term-based groups for multiple reasons. First, term-based groups reduce the introduction / adjustment period to a minimum which allows members to focus on group learning rather than introductions. Second, to allow groups to grow together. Third, to allow themes related to group dynamics to develop over time.

The SRS chosen for this study was developed by TurningTechnologies. Each student was provided with a response device which they used to answer true/false multiple-choice questions. Once the polling session was closed, aggregate responses were directly available and projected by the system. A feature of this system is the ability to re-poll and collect data on previously used questions without the need to stop the quiz and create a replica of a previous question.

Similar to Crouch & Mazur’s peer instruction method (2001), each class began with a closed book, closed notes SRS quiz activity. The parameters for each quiz are as follows: For each new question, students must respond individually with no assistance from others. If the correct response rate was below 70%, the instructor provided groups with the opportunity to discuss the current topic. Once group discussions were complete, the instructor posed the same question once again. After each question (repeat or non-repeat), the instructor would provide the class with the correct answer, open the topic for further discussion as needed, and then move on to the next question.

Data Collection

To evaluate Hypothesis 1 and 2, surveys were administered at the end of the semester for all sections. Data gathered from the surveys consisted the student’s impressions of the SRS, their group learning experience as driven by the SRS, and interpersonal skill development in the areas of communicating, collaborating, and working with diverse perspectives. To evaluate Hypothesis 3, our measures of learning effects include student performance on quiz and midterm questions. In total, there were five quizzes, and each contained approximately 12 questions. A subset of those questions was on the midterm. Quiz / midterm question pairs fell into one of two categories. Category A consisted of the no group discussion question set (e.g., above 70% correct response rate). Category B consisted of the first response to the more difficult questions (e.g., less than 70% correct response rate) which is followed by a group discussion. After the group discussion, the question was polled again. We did not use the second responses for analysis as we are interested in the influence group discussions have on content mastery.

Results

We analyzed data in multiple steps. First, we used descriptive statistics to represent student perceptions on learning in the SRS driven collaborative learning environment. Second, we performed statistical analysis on the distributions of pre-scores (quiz) and post-scores (midterm) for the individual and group question categories. Lastly, we employed a matched sample t-test to determine if group discussions significantly improve the overall midterm exam performance. A midterm score that is significantly different than the quiz score would indicate a positive influence on content mastery.

Research Hypothesis 1

Hypothesis 1 predicts that students will have a positive perception of SRS use for group learning. Our testing of H1 is dependent on responses to survey questions (Table 2). Survey results show that an overwhelming
The majority of students perceive the SRS/group combination as positive. The results of the survey are accurate at the 95% confidence level plus or minus 10 percentage points. Ninety-four percent of students provided a positive response to liking the incorporation of an SRS for individual/group quiz activities and 85% responded positively to taking more classes that use SRS-based quiz activities combined with groups (respectively means of 4.7 and 4.43). Individual comments suggest a favorable reaction to the SRS/group combination: "the clicker/group-based quizzes were fun and made learning easier" (participant #80), "very engaging and very useful! Exceeded my expectations! Made this class so much easier but challenged me as a student as well" (participant #37), and "clickers were fun and it made you actually think before answering" (participant #91).

<table>
<thead>
<tr>
<th>Sec A</th>
<th>Sec B</th>
<th>Sec C</th>
<th>Sec D</th>
<th>All Sec</th>
<th>Positive Ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td>n=38</td>
<td>n=35</td>
<td>n=36</td>
<td>n=22</td>
<td>n=131</td>
<td></td>
</tr>
<tr>
<td>I like the incorporation the SRS for the individual/group quiz activities.</td>
<td>4.78</td>
<td>4.75</td>
<td>4.52</td>
<td>4.75</td>
<td>4.70</td>
</tr>
<tr>
<td>I would like to take more classes that used SRS quiz activities in group settings.</td>
<td>4.52</td>
<td>4.65</td>
<td>4.24</td>
<td>4.43</td>
<td>4.43</td>
</tr>
<tr>
<td>I feel as if the SRS/group learning experience helped me better learn course materials.</td>
<td>4.51</td>
<td>4.57</td>
<td>4.70</td>
<td>4.28</td>
<td>4.51</td>
</tr>
<tr>
<td>The course was more engaging due to the SRS/group aspect.</td>
<td>4.57</td>
<td>4.70</td>
<td>4.36</td>
<td>4.67</td>
<td>4.57</td>
</tr>
</tbody>
</table>

Notes
- Items measured on a 5-point Likert Scale from Disagree (1) to Agree (5)
- Positive ratings is defined as a 4 or 5 out of 5 on the Likert scale

Table 2. Student perceptions of the use of an SRS for group learning

Research Hypothesis 2

Hypothesis 2 predicts that students perceive diverse group engagement as a positive influence on communication, collaboration, and learning (Table 3). Survey results indicated that 80% responded positively when asked if they found their group’s diverse perspectives helped them learn. The following comments further supported learning from diverse perspectives:

- I liked it [working in groups]. If we had different perspective, we were always able to discuss and agree on one thing (participant #15).
- I think groups are a good thing because it gives you another perspective of the topic (participant #20).
- We understood the material better, since we all would have different views on certain aspects (participant #119).
- It was beneficial to see a different perspective of why some of them thought the answer was wrong or right (participant #127).
- [working in groups] gave me a chance to look at different perspectives from my own (participant #130).

In addition, results suggest that students did learn to better communicate with their group members (mean of 4.48). Open-ended responses included:
• Being able to communicate with my group was great because without them I would be failing miserably (participant #8).

• My group was very knowledgeable and explained terms in a way that helped me grasp the concept (participant #13).

• I really liked the group-based clicker quizzes. I know that I retained more information because I was able to talk through my mistakes right after I made them (participant #51).

• [working in groups] made me think more about my answers and how to communicate this with my group members (participant #93).

Survey results also indicated that 87% of the students responded positively to feeling that their group learned more together than they would have individually (mean of 4.67) and 78% responded positively to feeling as if others had learned from them during the clicker quizzes (mean of 4.24). Individual comments supporting collaborative learning include:

• It was nice not to be solely dependent on yourself; you could combine thought process with other students to produce an outcome (participant #2).

• It was a good experience. If [some]one in the group did not know something, others would help them (participant #38).

• I liked being able to work together with other people. It helped me grasp concepts I wouldn’t have gotten on my own (participant #77).

• I loved the group based clicker quizzes. I like working with a group because I get a better understanding of the material (participant #85).

<table>
<thead>
<tr>
<th></th>
<th>Sec A n=38</th>
<th>Sec B n=35</th>
<th>Sec C n=36</th>
<th>Sec D n=22</th>
<th>All Sec n=131</th>
<th>Positive Ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td>I feel my group learned more together than we would have individually.</td>
<td>4.51</td>
<td>4.61</td>
<td>4.65</td>
<td>4.24</td>
<td>4.67</td>
<td>87%</td>
</tr>
<tr>
<td>I feel as if others had learned from me during the SRS quizzes.</td>
<td>4.21</td>
<td>4.17</td>
<td>4.25</td>
<td>3.16</td>
<td>4.24</td>
<td>78%</td>
</tr>
<tr>
<td>I found my group's diverse perspectives helped me learn.</td>
<td>4.26</td>
<td>4.23</td>
<td>4.40</td>
<td>4.20</td>
<td>4.43</td>
<td>80%</td>
</tr>
<tr>
<td>I feel that I learned to better communicate in group settings.</td>
<td>4.25</td>
<td>4.30</td>
<td>4.30</td>
<td>4.08</td>
<td>4.48</td>
<td>76%</td>
</tr>
<tr>
<td>In this class, I like being part of a group and being provided with the opportunity to learn from each other.</td>
<td>4.61</td>
<td>4.90</td>
<td>4.60</td>
<td>4.52</td>
<td>4.67</td>
<td>92%</td>
</tr>
</tbody>
</table>

Notes
- Items measured on a 5-point Likert Scale from Disagree (1) to Agree (5)
- Positive ratings is defined as a 4 or 5 out of 5 on the Likert scale

Table 3. Student perceptions of communicating and learning in diverse groups
Research Hypothesis 3

Hypothesis 3 predicts that clicker driven group discussions significantly improve mastery of course contents. Our testing of H3 relies on the quiz scores and midterm scores of the Category B question set (group discussion). The matched sample t-test for the mean scores on quizzes and midterms showed a significant improvement in the average student performance on the midterm compared to their performance on the quizzes, when students discussed quiz questions in groups (t-test statistics = 4.82, p-value = .0000). The average improvement is close to 11 points, and the 95% confidence interval for the mean score improvement is between 6.4 and 15.2 points.

As a counterpart to hypothesis 3, we analyzed the no group discussion data set (Category B) for an increase in content mastery. A matched sample t-test for the mean scores on quizzes and midterms revealed no statistical significance (t = 2.14, p-value = .1632). While answers to questions were provided during the quizzes, student performance on the midterm exam did not change significantly when students worked on questions alone.

Student Pre- Post-Exam Performance

In Figure 1, we present the two datasets of scores for the 131 student participants. The first dataset (Category A) consisted of no group discussion question scores. Here, the quiz scores are skewed left which implies that most of the students did well on those questions. Only 11% of the students missed the questions in this dataset. The second dataset (Category B) consisted of responses to the group discussion question set. In this category, 61% missed the question on their first attempt. This result highlights the level of difficulty of the question, student preparedness or both.

Histograms in Figure 2 are consistent with our third research hypotheses. There is a noticeable quiz/midterm improvement of almost 11 points in the average student performance with the group discussion question set. For the questions that were not discussed in groups (Figure 1), the average midterm score is 81 points and is slightly lower than the average quiz score. The discovery of a slight reduction was an unexpected finding as answers were provided at the close of each question poll.

The improvement in student performance following the group discussion becomes even more evident in Figure 3. The 75th percentile for the midterm scores for the group discussion question set moved up from 75 points to 82 points. In addition, more than half of the students (59%) received a passing grade on the repeated midterm questions compared to 39% of students on their quiz attempt.
Questions for group discussions were selected based on student performance. Table 2 shows the comparisons of the mean scores with and without group discussions for quizzes and midterm exams. The average quiz scores are significantly lower for questions that were discussed in groups (p-value = 0.0000), which reflects the perceived level of question difficulty.

<table>
<thead>
<tr>
<th>Category A: No group discussion question set</th>
<th>Category B: Group discussion question set</th>
<th>Discrepancy</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANOVA - Quiz Avg.</td>
<td>83.21</td>
<td>52.99</td>
<td>108.60</td>
</tr>
<tr>
<td>ANOVA - Midterm Avg.</td>
<td>81.07</td>
<td>63.78</td>
<td>32.84</td>
</tr>
</tbody>
</table>

Table 2. Mean Comparisons of the Scores with and without Group Discussions

Conclusions

Our primary objective of this study was to gain a better understanding of how a student response system can be used to facilitate the development of 21st century skills and mastery of course content or domain knowledge. More specifically, do students perceive SRSs as beneficial and how can the student response system be used to engage the students in a learning experience that advances their 21st century skills and domain knowledge. We tested our hypothesis using a sample of 131 undergraduate students. Our results provide strong support that student perceive SRSs as beneficial to group learning, students perceive group engagement as a facilitator to the development of 21st century skills and mastery of course content. In addition, the results provide us with the opportunity to contribute to the current research base in multiple key areas.

To begin, our data analysis allows us to understand the association between our SRS driven group learning model and how students perceive their 21st century interpersonal skills development. By fostering peer interaction and enabling intellectual exchanges, the SRS driven group learning model helps students become exposed to and develop interpersonal, communication, group, and diversity skills. This might be because our SRS model engages students in discussing their ideas, exploring diverse understandings, and working together to find solutions, all of which contribute to an increased exposure to peer interactions and through this process, to further their 21st century interpersonal skills.

Consistent with prior research, student survey responses indicate a strong satisfaction with the SRS environment. In addition, students proclaim positive effects of SRS driven group discussions on learning.
We consider the interplay of the SRS and the group interactions to be a positive influence on both learning and satisfaction. When group learning was not existent in the SRS environment, exam performance suffered but we don’t believe it was enough to negatively influence satisfaction ratings. To this end, when faculty incorporate an SRS in their course, they must also consider the how to best engage students in a group learning experience.

Additionally, it is important to note that the SRS identifies the student knowledge gaps (i.e., below 70% correct response rate on individual questions) in need of an educational intervention. The primary intervention comes in the form of focused group discussions that foster further engagement through communication, critical thinking, knowledge sharing, and ultimately collaborative learning. An important result of this process is a significant improvement in knowledge over time. In addition, students claim the SRS based group discussion is beneficial to their learning process. More so, students perceive that they learn more in a group than they learn when working individually. Students also indicated that within group discussions, diverse perspectives were an influential factor for learning, and their input is considered by group members. These results strongly support the use of an SRS to promote communication and interaction amongst group members which, ultimately, enhances learning.

This study provides preliminary conclusions about SRS satisfaction, and its effects on interpersonal skill development and learning (group and individual). Through the course of this study, limitations were present and opportunities for future studies revealed themselves. The first limitation was the influence of the sole faculty member across all study groups. While we believe the single instructor provided consistency across groups, the instructor’s pedagogical approach might have influenced the student interaction and survey responses in either a positive or negative direction. While we cannot exclude this possibility, results support our objective findings and are consistent with prior research. Further research into different pedagogical approaches and SRS driven group learning may provide a deeper understanding on this topic.

Our second limitation is our inability to make inferences about group dynamics and their influence on group learning due to our research design. While we did notice an emergent peer leader among the groups, further research is needed before we can conclusively identify such a leader and the type of influence, she/he might have on group performance.

Also, our study was performed in a freshman course that is based on high level materials. It is possible that mastery of some of the materials is obtainable with minimal exposure which, consequently, restricts our ability to infer our findings on higher level courses that require a substantial amount of invested time to master course content. An examination of our SRS group learning model in higher level courses may provide further support for SRS driven group learning.

To conclude, we assert that it is very important help students obtain interpersonal skills as early as possible during their college years. In creating a learner-focused environment, instructors could, for instance, utilize tasks and activities that foster peer collaboration and teamwork. Further, when in-class activities embed new academic concepts, ideas, or themes students will have opportunities to compare and analyze the given task from different perspectives and thus strengthen their interpersonal skills.

IS departments and faculty must continue to look for creative and innovative ways to integrate interpersonal skills building in the program curricula. For example, students could be afforded the opportunity to communicate their thoughts, interact in a group setting, and listen to differing perspectives and viewpoints as part of normal and regular course activities. In this way, students gain appropriate academic skills while learning to seek assistance from others for tasks, situations and activities that will be presented to them during their post-collegiate career and life which cannot be resolved or completed without the help and support of their future colleagues.

REFERENCES


