Students' Perceptions Of the Implementation of a Cyberlearning Tool

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Abstract
A cyberlearning tool was developed to facilitate teaching and learning of software engineering courses. The tool, SEP-CyLE (Software Engineering and Programming Cyberlearning Environment), was developed by a publicly funded research university and is currently being used by at least seven other universities across the United States of America. The National Science Foundation (NSF) provided funding for the development and implementation of the tool. Since its initial development the scope of the tool has been expanded for use in other university level computer science courses.

The three learning engagement strategies (LESs) that are an integral part of the tool are (i) collaboration, (ii) gamification, and (iii) social interaction. This paper focuses on the gamification strategy that was implemented in multiple sections of an introductory computer programming course at a university that was one of the locations for the multi-site project funded by the NSF.

A study was conducted to determine students' perceptions of the cyberlearning tool and how it was implemented. Data for the study were obtained through interview and focus group sessions. The data were transcribed to extract the major ideas expressed by the students during the interview and focus group sessions. The findings are presented and discussed. The usefulness of the tool and the motivational aspects of the gamification strategy are explored as well. The paper provides suggestions from students for improving the tool and recommendations on how SEP-CyLE should be implemented in classrooms.

The main contributions of this work are as follows:
1. The cyberlearning environment or tool that was developed with funding from the NSF was considered to be useful and user friendly by students who used the tool.
2. Gamification was considered by students to be motivating.
3. Students suggested that the tool should be used as an integral part of the course rather than as an add-on.

1 Introduction

Employment outlook for students with computer science degrees is very good. The United States Department of Labor Statistics has predicted a 24% rise in employment for software developers in just ten years from 2016 to 2026 [1]. A highly-compensated career with high demand that is achievable with a bachelor's degree is fueling student interest in computer science as a major. Students are highly motivated to learn as they enter their first programming course, CS1 [2]. Yet, the pass rate for CS1 courses has been reported to be as low as 67% [3]. Many possible reasons for high attrition have been proposed ranging from inadequate advising to poorly-designed activities in CS1 laboratories to insufficient opportunities for meaningful practice with formative feedback [4]. Increased student engagement in introductory programming courses may be one route to increasing retention in CS1 courses.

Collaboration, gamification, and social interaction are considered to be three pedagogical strategies which aid in engaging students in learning. Teague and Roe [5] conducted a survey of students and their findings indicated that students considered collaboration to be a positive way to learn programming. A study by Fotaris et al. [6] found gamification to not only be motivating for students, but also showed improved learning of programming concepts throughout the course. Meltzoff et al. [7] also consider social interaction to be essential for learning.

SEP-CyLE, a cyberlearning system developed at Florida International University, is being used at seven universities in computer science programming and software testing courses to supplement existing course materials [8]. SEP-CyLE consists of five major components and numerous sub-modules as shown in the following high-level block diagram.

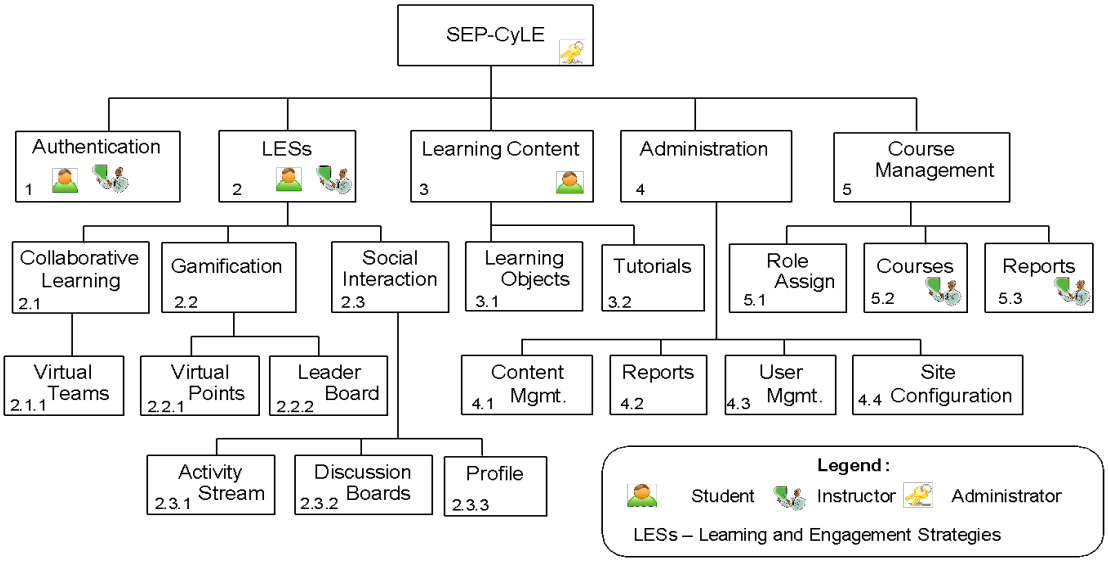

Figure 1: Block diagram showing the main components of SEP-CyLE

The major components of the cyberlearning environment are described as follows.

1. *Authentication* - provides various users with different levels of access. These users include students, instructors and administrators.
2. *LESs* - the learning and engagement strategies include collaborative learning [9], gamification [10] and social interaction [11].
3. *Learning Content* - contains the digital learning objects (DLOs) [12] on various SEP topics and tutorials for several SEP tools.
4. *Administration* - provides the administrator with the ability to generate various reports (number of users, types of users, etc.), configure the system, and coordinate the course management activities.
5. *Course Management* - generate student reports for instructors and individual students, assignment of student and instructor roles.

A summary of how SEP-CyLE implements the LESs are listed below.

- Collaborative learning – use of collaborative virtual teams, teams collaborating to complete online assignments, posting comments on the work of other teams.
- Gamification - virtual points, a leader board, allocations of points based on various activities (e.g., completing assignments, posting to a forum, completing a user profile, and posting

helpful learning content that benefit others).

- Social interaction - user profiles, message forums, group/individual chat, ratings and comments on learning content.

The cyberlearning tool provides a course level management view in which instructors can upload a student roster for a course, select from existing learning content in the form of digital learning objects and tutorials, assign the content to students with configurable points, due dates, etc., and include a selection of Learning Engagement Strategies to be used in the course. Additionally, student activity, such as time spent in the content area, practice area, and quiz areas within SEP-CyLE is monitored and can be retrieve along with quiz scores and virtual points earned for each student.

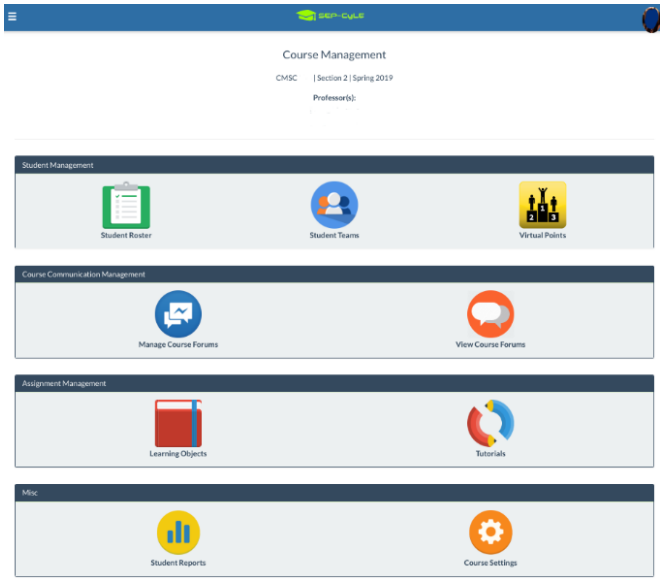

Figure 2: Instructor view of SEP-CyLE course management page

The current SEP-CyLE system consists of several dozen Learning Objects (LOs) developed by the PIs and Co-PIs of a National Science Foundation (NSF) funded project. The three major pedagogical themes or Learning Engagement Strategies (LES) embedded in SEP-CyLE are (i) collaboration, (ii) gamification, and (iii) social interaction. This paper presents some results from focus group sessions conducted with students who experienced SEP-CyLE in their computer science courses at Virginia Commonwealth University (VCU) an urban, public research university located in the mid-Atlantic region of the United States, one of the seven institutions mentioned previously.

2 Overview of the Literature

The relevant literature on collaboration, gamification and social interaction are reviewed and a succinct overview of such literature is provided in this section of the paper. The purpose of this overview is to show that there is sufficient research-based evidence in the professional literature regarding the positive impacts of incorporating collaboration, gamification, and social interaction in computer science courses at the undergraduate level.

2.1 Collaboration

The concept of collaboration or collaborative learning (CL) consists of an environment, either virtual or face-to-face, in which learners work together in groups on a goal-oriented activity, such as solving a problem or creating a product [13]. The characteristics of CL include individual responsibility, peer respect, appreciation of member's abilities and contribution, and shared authority [14]. Collaboration is based on consensus building and team work among group members, rather than competition for individual recognition. Therefore, each member assumes responsibility for the success of the group as a whole in accomplishing its goal.

The benefits of CL have been categorized by Laal and Ghodsi as social, psychological, and academic [14]. The social benefits include providing a support system of learners, building an understanding and appreciation of diversity, allowing for the practice of cooperation, and developing learning communities. Psychological benefits include greater self-esteem, anxiety reduction and higher regard for instructors. Finally, academic benefits include promoting critical thinking and active learning, enhancing problem solving skills, improving classroom results, and helping to reduce the impersonalization in large classes [14]. A survey of introductory programming students by Teague and Roe found that they believe CL enhances the study of programming and leads to better learning outcomes [5].

Dillenbourg describes a collaborative *situation* as a social contract in which interactions are expected to occur, but not guaranteed to occur [13]. In SEP-CyLE collaboration is implemented in the form of instructor-created groups who may work together to complete an assigned task (completion of a specific learning object (LO)). The group is rewarded when all members complete the task at a prescribed level, such as 80% correct for the quiz, and if the entire team completes the task before other teams. So, members are encouraged to help each other work through the learning object and encourage their teammates to complete the prescribed activities in a timely manner.

2.2 Gamification

The widely-used term "gamification" is defined by Deterding et al [15] as "*the use of game design elements in non-game contexts*" and became more widely adopted in late 2010. The usage of gamification in education is to introduce the beneficial motivating factors from games to offset frustrations and a lack of engagement often present in educational contexts. A review of the literature by Hamari, Koivisto, and Sarsa [16] indicated that overall, gamification produces positive effects on student engagement and has been shown to lead to improved student outcomes compared with courses not employing gamification strategies. Research has also shown that gamification has a positive impact on student learning by encouraging continuous practice [17] [18].

Some of the most commonly used elements of gamification mentioned in the literature are awarding participation and achievement points for completing work assigned by the course instructor [19], leaderboards where students can track and compare their achievements with peers [20] [21], and awarding badges to reward accomplishments [22]. Leaderboards and point systems were shown to be particularly effective in encouraging higher motivation and participation [23]. Both of these strategies are integrated as an integral part of the gamification function of SEP-CyLE.

2.3 Social Interaction

A student who is actively engaged in their learning can be thought of as one who is committed to participate in the learning process. Fredricks, Blumenfeld, and Paris describe three ways of defining school engagement – behavioral, emotional, and cognitive [24]. Behavioral engagement can be observed in the ways a student participates in school-related activities. Emotional engagement refers to the reactions or feelings that a student has to the school, academics in general, and their instructors and classmates. Cognitive engagement describes the degree to which a student exerts the mental effort required to comprehend and synthesize complex information and develop the necessary skills for successful pursuit of advanced knowledge in an area. For example, the study of computer science relies on programming skills.

Students engage in their learning at various degrees with highly engaged students persisting and achieving their learning objectives to a greater degree [25]. For a given student the level of engagement may vary by both type and degree over their academic career and may be enhanced in response to the educational environment [24]. SEP-CyLE facilitates social interaction by providing students the opportunity to upload a personal photograph or other representative image to their profile. They may include a personal profile to help connect with other students over shared interests. Additionally, students have access to an area of the site for the exchange of ideas in a virtual discussion format.

3 Purpose of the Study

An important factor in the initial evaluation of a new technological educational tool such as SEP-CyLE is the perspectives of student users. The purpose of this study was to explore the thoughts and perceptions of students who used SEP-CyLE in their computer science courses.

This qualitative study will address the following research questions:

- Research Question Number 1: What do students think about SEP-CyLE and the three learning engagement strategies?
- Research Question Number 2: What strategies for implementing SEP-CyLE in a course are most effective?
- Research Question Number 3: What do students think about how SEP-CyLE should be used in a course?

Answers to the above research questions can inform educators in successfully implementing SEP-CyLE in classrooms as well as help to identify ways in which the cyberlearningsystem may be improved.

4 Study Methods

According to Kontio, Lehtola, and Bragge, focus groups can be useful for various purposes, including “Initial evaluation of potential solutions, based on practitioner or user feedback” and “Collecting lessons learned recommendations” [26]. Because the research questions in this study are similarly focused on collecting broad user perspectives, focus groups are an appropriate method for data collection in this study.

The data collected consists of responses and discussion provided by students in classes in which SEP-CyLE was implemented. Five thirty-minute focus group sessions were conducted over a

period of two days to obtain exploratory data regarding students' thoughts and perceptions about their experiences using SEP-CyLE in their classes. One individual ten-minute student interview was also conducted.

Study Participants in the 2017-2018 academic year consisted of 145 students who had completed both learning objects in SEP-CyLE and knowledge assessment tests before and after the course. Study participants self-reported demographics information at the beginning of the semester. Overall, the participants were 65% male and 28% female, with 7% in another gender category or electing to not report gender. The focus group participants were 56% male and 44% female. Of the 145 participating students, 32 students participated in the focus group sessions. Students who were enrolled in CS1 in the fall were invited to the focus groups along with spring semester students, so each focus group consisted of students currently enrolled in CS1 and CS2. However, the discussion was based entirely on each student's experience using SEP-CyLE during their CS1 course either concurrently, or in the previous semester.

Participating students in the focus groups were asked to generally describe their experiences using SEP-CyLE in their classes. Questions were also asked about the three learning engagement strategies. Follow-up questions were also asked based on their responses. The interview and focus group sessions were conducted by one of the educational researchers who was also one of the co-PIs of the SEP-CyLE project with prior approval of the Institutional Review Board (IRB) at VCU.

4.1 Analysis of the Focus Group Data

The audio recordings of the student interviews and focus group sessions were analyzed by reviewing the audiotapes and transcribing the main ideas and major points expressed by students. The purpose of the study was to determine student's perceptions of SEP-CyLE, the way the cyberlearning environment was introduced in their classes, and the students' involvement with the three learning engagement strategies of collaboration, gamification and social interaction. Because of this, the emphasis in data analysis was on capturing the various ideas voiced by the students regarding these topics.

5 Major Findings

The major findings of the interview and focus group sessions are framed by the three research questions that were stated earlier in this paper.

Research Question Number 1: What do students think about SEP-CyLE and the three learning engagement strategies?

5.1 SEP-CyLE Interface

Data from the focus group sessions indicate that students generally had a positive experience using SEP-CyLE. They considered the system to be user friendly and easy to use. Some minor complaints with the interface were an initial difficulty logging into the system for some students and the tests associated with some LOs were reported to have typographical errors. One student however, suggested that the look and feel SEP-CyLE could be updated to make it appear more modern, to resemble more popular social media platforms.

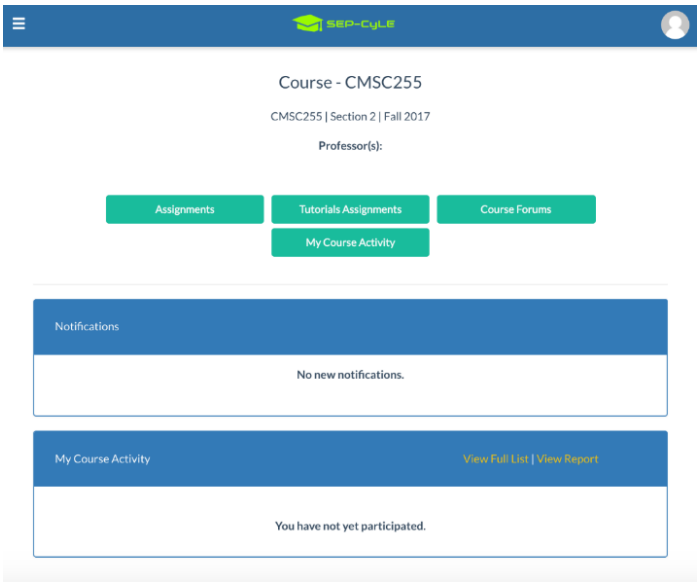

Figure 3 SEP-CyLE Student View

Table 1: Representative Statements Regarding SEP-CyLE Interface

Really helpful in explaining different coding...giving you examples for practice.
It was nice to use, really helpful.
The lessons are easily referenced from the practice quizzes, so I could go back to them.
Provided a really strong organized practice and a summary of what's going on.

5.2 Usefulness of SEP-CyLE

As indicated in the representative statements shown in Table 2, many students found SEP-CyLE to be useful as a study aid in preparation for tests and quizzes in the course. Several students reported that the use of SEP-CyLE reinforced course content and assisted with learning supplemental topics, such as software testing techniques. The following quote by one of the focus group participants emphasizes the perception that SEP-CyLE is a beneficial tool for learning programming concepts,

> *"I think there is like two ways of learning - there is learning to get the grade and there is learning to actually understand it. And so, it's kind of like a triangle, the SEP Cycle kind of connected in between. You learn to understand it in SEP Cycle, but there is the reward system, the points, to help you get the grade. Because I think it kind of completes the triangle to help improve the experience. Because otherwise a student goes for one path versus the other."*

Table 2: Representative statements regarding usefulness of SEP-CyLE

Quizzes were useful because it preps you better than quizzes in class.
Helpful for learning software testing concepts.
Used it as sort of a review for tests.
Helpful recapping curriculum.
Got extra practice

5.3 Gamification

Use of SEP-CyLE was a source of extra credit for all students in the course regardless of the learning and engagement strategy (LES) in their version of SEP-CyLE. Students earned virtual points in association with the learning engagement strategy of gamification in SEP-CyLE. These virtual points did not have any additional effect on a student's course grade, but rather the teaching assistant would occasionally recognize the student with the most virtual points in the lab section. Overall, the gamification aspect of the cyberlearning environment with virtual points was well received by most of the students who participated in the focus groups, as indicated in the representative comments in Table 3. While many students indicated that the point system was motivating, a few said that they were confused regarding which specific activities on the site were rewarded with points and as a result were less motivated by virtual points. Several students reported that awarding the highest-scoring student in class with a small prize each week was motivating and encouraged some students to participate more in SEP-CyLE.

Table 3: Representative Statements Regarding Gamification

During lab, they announced the places that people were in. I'm competitive, so that kinda helped me do more SEP-CyLE.
I noticed the points that others were earning.
Motivated me to complete more of them.

5.4 Collaborative Learning

Study participants who attended the focus groups reported that they rarely used the collaborative aspects of SEP-CyLE. When asked why this was the case, the overall consensus was that they were enrolled in a face-to-face course and worked together in groups the traditional way. They indicated that there was no need for them to collaborate online using SEP-CyLE. Other students mentioned that the assignment of random groups in SEP-CyLE negatively influenced their likelihood to collaborate within the cyberlearning environment. They reported that they often had not met the other students on their team, which caused reluctance to contact them. Students indicated that they may be more likely to interact with team members if they were introduced in person before attempting to collaborate online.

5.5 Social Interaction

Social Interaction was not a motivating feature for the students who attended the focus groups. Many of them stated that they had no idea that they could interact with others in their groups using SEP-CyLE. Students mentioned that they saw some messages from students from other universities in the comments section of the cyberlearning environment, but the messages were not recently posted. Some of these students were not aware of the social interaction component because this function was disabled for their section, but other students with enabled social interaction still were not aware of the function. When asked why this might be the case, focus group participants suggested this might be due to the rushed nature of the introductory demonstration of SEP-CyLE or because they did not pay close attention to the demonstration after being told that usage of the site was optional.

Research Question Number 2: What strategies for implementing SEP-CyLE in a course are most effective?

5.6 Introduction of SEP-CyLE in the Course

The introduction to SEP-CyLE was presented to all sections in the form of a demonstration of logging in, accessing Learning Objects, and using all of the features of the website. Members of the focus groups were asked to recall how they first learned about SEP-CyLE. Some students mentioned that the introduction was given at the beginning of a lab session, so they became distracted by the desire to begin working on the lab assignment and paid less attention to the demonstration. Other focus group participants recalled their impression that SEP-CyLE was introduced as "another thing to do" in the course. They communicated that the online system was not fully integrated into the course. Some students mention that for their class, SEP-CyLE was not introduced at the beginning of the semester but rather a few weeks after the semester had started.

Table 4: Representative Statements Regarding Introduction of SEP-CyLE

After we were introduced to SEP-CyLE we had to do a lab afterwards, so that was in the back of our mind. When I left lab, I didn't remember SEP-CyLE.
It's helpful to show students how to use SEP-CyLE.
It should be emphasized more at the beginning of the semester.
It was really confusing, at first, how it was introduced. I couldn't find the website.

5.7 Use of SEP-CyLE in the Course

According to some students in the focus group, there was a disconnect between the content covered in the course and the learning modules (LOs) in SEP-CyLE. Many of SEP-CyLE Learning Objects assigned to the study participants were focused on software testing, and software testing was not the main emphasis of their introductory computer science course. Because of this, many students said that the software testing LOs were only completed for credit and the students did not attempt to learn or retain that information. Conversely, the Learning Objects that students felt were directly related to course content were used in test preparation as supported by the representative comments in Table 2.

Research Question Number 3: What do students think about how SEP-CyLE should be used in a course?

5.8 Suggestions for Implementing SEP-CyLE In Courses

According to students who participated in the focus group sessions, SEP-CyLE was generally easy to use, however a comment by one student suggested that the look and feel of the system could be more modernized. SEP-CyLE is being continuously upgraded and many of the issues students encountered such as not being able to access LOs have been resolved. Suggestions made by the students are also being incorporated in newer versions of the tool.

A number of suggestions emerged from the focus groups that course instructors who implement SEP-CyLE in their courses may find helpful. Here are some interesting ones.

- The learning environment should be introduced to students very early in the semester and instructors should follow-up with students to resolve any difficulties they may be experiencing.
- Course instructors should consider incorporating SEP-CyLE as a fully integrated part of the course rather than for supplementary course content.
- Instructors are encouraged to organize collaborative groups in the face-to-face classroom and retain the same student groups in the cyberlearning environment to enhance both collaboration and social interaction.
- Students reported using SEP-CyLE towards the end of the semester in order to earn extra credit to help improve their grades. To encourage students to use the system throughout the semester, instructors can require students to complete weekly assignments that necessitate the use of all three learning engagement strategies that are built into SEP-CyLE.

6 Conclusion

Students found the SEP-CyLE cyber-learning environment easy to use and helpful in their learning of topics directly related to those taught in their CS1 course. As indicated in Table 2, they found the practice and formative feedback useful as a study guide in preparation for course examinations. Of the three learning engagement strategies implemented in SEP-CyLE, students felt that gamification was the most motivating, as the comments in Table 3 indicate. Many students suggested that the cyberlearning tool be introduced at the beginning of the semester and be an important, integrated part of the course, rather than using it to supplement topics not generally covered in CS1.

The data collected during the focus sessions indicate that there is a need for developing additional Learning Objects that cover more content areas, especially in areas that are directly relevant to course material. The development of LOs is an important and ongoing activity that is being emphasized by the PI of the project. More LOs will be developed by both the SEP-CyLE team and collaborating educators in the near future to ensure that SEP- CyLE can be used in various content areas and courses in Computer Science.

As SEP-CyLE continues to evolve and as more information is collected regarding its implementation in classrooms in educational institutions across the country, it is likely to become

a valuable tool that students and instructors can use to facilitate teaching and learning in computer science courses.

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