Project Evaluation Report (2017)
YEAR 3

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Introduction

This is an assessment report covering the third year in the three-year grant, *Gamified Digital Forensics Course Modules for Undergraduates*, PI Yin Pan, Co-PI Sumita Mishra. The project has been extended for one additional year, so this is an interim evaluation report. The full project team consists of faculty from:

- Rochester Institute of technology (RIT), a private four-year university;
- Onondaga Community College (OCC), a public two-year institution, and;
- Corning Community College (CCC), a public two-year institution.

Major Project Goals and Objectives:

This project is designed to enhance digital forensics curricula starting at the entry-level for both 2-year and 4-year college by *gamifying* forensics content utilizing game-based learning (GBL) approach. The primary project objectives are to:

1. Develop a sequence of fun, entertaining, and educational *game-based digital forensics* course modules to enhance digital forensics curricula and help create a pathway for students in forensics programs from two-year colleges to four-year institutes (Curricular Goal).
2. Develop faculty expertise, targeting two-year college faculty, in digital forensics and security through collaborations within and between partnering institutions (Faculty Goal).
3. Disseminate the game-based forensics course modules to community colleges and universities through workshops, tutorials/panels, online-resources such as the ATE Centers, published papers, and conference presentations (Dissemination Goal).
4. Assess the effectiveness of the games-based course modules via a comprehensive evaluation plan utilizing an external evaluator and a variety of data sources (Assessment Goal).

General Progress Toward Major Project Goals and Objectives

1. The development of the course modules was completed in 2016, and the project has moved to the dissemination phases.
2. This year, for the second year in a row, modules were disseminated and tested in multiple schools – three community colleges and two four-year universities. Evaluation results show that

the game-based modules were generally well-received and were preferred by students (compared to other more traditional labs).

3. The modules appear to be effective in teaching the processes of digital forensics. Although some students expressed dislike or ambivalence toward the gamified labs. (As explained below, the less favorable ratings were largely from one of the 4-year universities, not the community college audiences. This was consistent for the past two years.) In previous project evaluations, we had assessed a subset of specific student learning outcomes. This year, learning objectives related to students' use of tools and the reasoning process in forming forensics conclusions were investigated. There was ample evidence that learning occurred as students were able to use professional tools as they reasoned through simulated scenarios.

Project Evaluation

The following table summarizes the project evaluation design. Ongoing answers to selected evaluation questions (Questions 3, 4, and 6) follow. Note that some evaluation methods may have been modified as the project has developed.

Table 1: Summary of project evaluation design

Evaluation Questions	Data Source	Methods and Measures	Schedule
1. Is the game infrastructure flexible and user-friendly for plugging-in modules	Design team, adopting instructors, advisory Board and expert review from HCI Interaction Designers.	Open-ended comments and identification of weaknesses in interface, and content.	Usability testing of each module will be done during development
2. How easily and effectively are modules integrated into existing curricula?	Design teams and adopting instructors at each educational level	Lesson plans and curricular material. Instructors' feedback rating useful component modules, ease of use, time to introduce the topic, and appropriateness of indicated module prerequisites.	Collected from instructors after the class
3. Are GBL modules effective for students at each educational level?	Pre-test for each student before the module is taught. Post-test for each student for each GBL module after the module is taught that includes authentic assessment of skill.	a) Use of rubric for direct authentic post-test b) ANOVA (paired t-test) comparing pre and post test scores (per student, per module) as percentages of knowledge and skill accounted for by individual module c) Student formative comments regarding value of specific module instructional components	Collected from students pre and post module for each GBL module
4. To what extent is each of the five DF learning outcomes, listed in 4.2.1, attained.	Assessment data from students for each module that contributes to each DF learning outcome (as identified in each module). Additional measures of time-on-task from system logs.	Authentic assessment of student skills, measured by written exams, and success with hands-on activities within the GBL system. Direct assessment of knowledge and skills with post-tests for each module.	Direct assessment of knowledge and skills with post-tests at the completion of each module. Time on task logs to be gathered at the completed of each module.

5. How can the GBL modules be improved?	Expert review from Instructional Designers, HCI Interaction Designers, Students, and Advisory Board.	Open-ended comments and identification of weaknesses in instructional strategies, interface, and content.	Usability testing of each module will be done during development. Student comments will be gathered at the completion of each module.
6. What are students' attitudes toward further education and careers in Forensics?	Freshmen who are first introduced to forensics field	Pre- and post- test using Likert-scale attitudinal scales of student perception of the Forensics field and interest in security careers.	Collected from students at the conclusion of 100-level and 200-level modules.
7. How supportive are experts in the field to the GBL approach?	Survey data from faculty and other experts at the faculty workshop	Likert-scale attitudinal scales of interest in the GBL Forensics course and approach. Count of what modules are adopted at other schools Count of faculty and expert participation in workshops and dissemination events Count of requests for materials Count of course adoption at other institutions	Collected from faculty and expert participants at the end of each dissemination event and ongoing monitoring of materials

This evaluation concentrated on three aspects of the project evaluation: evaluation questions 3, 4, and 6 from the table above.

Evaluation Question 3:

"Are GBL modules effective for students at each educational level?"

In Spring, 2017, the Game-Based module was used at five different schools, across more than 100 students. The game based modules were used in a variety of introductory computing security courses. 76 students participated in an online survey consisting of eight questions (attached).

PARTICIPANTS BY SCHOOL (76 total)

Participants in the survey were students who are enrolled in computing security courses at five different schools. Of the original N=76 students, several responses were eliminated from the study.

- 2 respondents were deleted because they could not get the tool to work at all and were not able to open the software on their computer
- 3 respondents were deleted because they did not complete the survey beyond identifying their institution

School/Institution	Number of Participants
Corning Community College (CCC)	18
Finger Lakes Community College (FLCC)	1
Onandoga Community College (OCC)	12
Pennsylvania College of Technology(PCT)	9
Rochester Institute of Technology (RIT)	31

Table 2. Participating Institutions

An electronic survey was supplied to students at the conclusion of the lab. Students were asked a series of questions related to recall, skill use, previous knowledge, and the degree of interest in the gamified lab, along with interest in the field. As noted, not all students answered all questions – and five students were removed from the analysis when a non-answered question interfered with the analysis. It is interesting to note that several sites reported more students who were in the course who did not ultimately complete the survey.

To answer the question more thoroughly in this evaluation cycle, some data were analyzed (a) by school and also (b) based on previous knowledge.

OVERALL PREFERENCE FOR EDUCATIONAL TECHNIQUE

Students were asked for a forced-choice response to the question: "Do you prefer this game-based approach to learning compared to your other labs?" Because the game-based lab was our research treatment, we tested our results against the assumption that there was no preference in the educational technique. The Chi-Square goodness-of-fit test was used. The chi-square goodness-of-fit test is used to test if a sample of data came from a population with a specific distribution, in this case a uniform distribution. If there were no preference effect, the hypothesis is that all responses would be equal.

The results show a slight preference for the game-based technique.

PREFERENCE	Count (N)
I prefer the game-based lab	28
No preference	23
I prefer the other labs	20

Table 3. Student Preference

The Chi-Square value is 1.382. The P-Value is 0.501. The uniform distribution result is *not* significant at $p=\leq 0.05$. This suggests that there is enough difference that the results are not uniform. These results suggest an overall slight preference for the game-based lab compared to the other labs.

PREFERENCE BY LOCATION

Past evaluation reports suggested that there was a difference in preference between 2-year schools and a 4-year school, with higher preference occurring in 2-year institutions. This year, anecdotal evidence from the instructors again suggested that the preference may not be equal across all locations. Although no statistical test has been done on this data, it appears as though preference is clearly different at the various locations. The game-based module was the clear preference at CCC, FLCC and PCT. As an interesting effect, at RIT (the 4-year institution), the "other labs" technique was preferred by more than half of the students. These differences are highlighted in the table. Note that OCC had only 3 participants, and 2 were removed from the study because they did not actually get the software to run.

This result is consistent with last year's evaluation that also showed a preference by institution. This is still somewhat unexplained, and will be followed up on in the next round.

	Other Labs	No Preference	Game-Based	Count (N)
CCC	16.7%	38.9%	44.4%	18
FLCC	8.3%	58.3%	33.3%	12
OCC	0.0%	0.0%	100.0%	1
PCT	0.0%	22.2%	77.8%	9
RIT	51.6%	22.6%	25.8%	31

Table 4. Student Preference by Institution

Evaluation Question 6

"6. What are students' attitudes toward further education and careers in Forensics?"

We directly asked students a survey question to determine if their attitudes and interest in Forensics had changed. (Although we had planned a pre-post test approach, asking students about a "change" seemed to be more direct in this round.)

CHANGE IN INTEREST IN THE FORENSICS FIELD

One of the major goals of the project was to increase interest in the area of forensics and the field of computing security. Students were asked for a forced-choice response to the question: "After this module, did your interest in the field of computer forensics change?"

The results visually suggest that only 3 students' interest were moved in a negative direction. While many students (30) were unchanged, still **a majority of students' interest (38) were moved in a positive direction.** Looking at the hypothesis that responses should be uniform across the distribution, the Chi-Square goodness-of-fit test was used. The Chi-Square value is 79.6. The uniform distribution result is *not* significant at p=≤.0001. Therefore, this is clearly not a uniform distribution. This suggests that overall, the project was successful in moving students interest in computing forensics in a positive direction.

Change in Interest	Count (N)
A lot more interested	3
More interested	35
Unchanged	30
Less Interested	1
A lot less interested	2
No answer	*(1)*
TOTAL	72

Table 5. Change of Interest in the Forensics Field

CORRELATIONS

Although it is a truism that correlation does not imply causation, for exploratory purposes, we looked at a set of correlations that might suggest which factors contributed to the increased interest in the field of computing. The Pearson *r* correlation between *preference for game* and *interest in the field* yielded a correlation of .449. This accounts for about 20% of variance, and it is generally accepted that a correlation for N=71 is significant at <.0005 if the Pearson *r* Is greater than .41.

	Previous knowledge	**Interest in the field**	**Preference for the game**
Previous knowledge		*r* = -.068	*r* = -.065
Interest in the field	*r* = -.068		***r* = .449***
Preference for the game	*r* = -.065	***r* = .449***	

Table 6. Cross-correlations between three student factors

*significant at <.0005
(http://www.oneonta.edu/faculty/vomsaaw/w/psy220/files/SignifOfCorrelations.htm)

This correlation supports the idea that the game-based module is related to a changed interest in the field. Although there can be other alternative explanations, it suggests that, in this context, the game-based module moved student interest in the field of forensics in a positive direction.

Evaluation Question 4.

"4. To what extent is each of the five DF learning outcomes … attained."

The following learning Outcomes were listed in the original project proposal. Previous evauation cycles have investigated other learning outcomes. In this evaluation cycle, we focused on Learning Outcome 3, identifying and employing forensic tools.

Learning Outcome 1. Describe digital forensics process and forensics procedures necessary for ensuring the admissibility of evidence in court.

Learning Outcome 2. Identify pertinent system and network information, and use court-approved forensics tools to retrieve admissible evidence. (Note: to be assessed in project year 3)

Learning Outcome 3. ***Identify and employ forensic tools to retrieve and analyze evidence of mobile devices***

Learning Outcome 4. *Write a forensics report with findings* ***following appropriate forensics process.***

Learning Outcomes 3: Identify and employ forensic tools…

Students at all sites were asked to identify the forensics tools that they used in the game-based lab. A simple count of the number of tools reported by students is shown in the table, with a range of 1-8 different tools that were named. Several students did not answer the question, and one student responded, "All kinds of tools" which suggested that the student did actually use the tools, but somehow failed to be able to identify the tools.

Number of Tools Identified	Count (N)
1	24
2	26
3	5
4-8	9
no answer	5

Table 7. Use of Forensic Tools

These results strongly suggest that the lab was very effective in teaching students to use the tools, and that the majority of students did use the tools and were able to identify the tools. (Note that several students included an explanation of what each tool actually was used for. In these cases, often the student ran out of characters in answering the question, and were cut-off, so the reported count may be lower due to this.)

Learning Outcome 4: …follow an appropriate forensics process

In the past, we have asked students to write a somewhat truncated forensics report. In this cycle of evaluation, we attempted to determine the reasoning process that students followed, rather than focus on an actual report. Students were asked "what data did you use to form your conclusion." 8 students did not answer, and one student noted that he/she was unable to form a conclusion. The remainder of the students listed a variety of data and information that was used as they formulated their conclusion

The following examples are typical responses:

- "We analyzed RAM, hard drives, documents, images, network logs and Wireshark captures throughout the various IPAR labs. All of which proved to be valuable information in the computer forensics process."

- "We looked at hard drive data, RAM dumps, images, logs of computers and network traffic."

- "I looked at a file that was mismatched in its data and type to see an image of the wife and the lover. I then looked at their internet history to see if there was any websites that the family use that could be suspicious and I look at a receipt that I found in the recycling bin that was made out for a vacation"

The student responses suggest that students were able to follow the logic of the particular case and were able to reason through the simulated case and form a conclusion based on the evidence that they gathered. It would appear as though students would be capable of writing a report – this cycle did not specifically ask for the writing, but found support for the logic and the reasoning process.

Conclusion

The project seems to be delivering more than it promised. In past evaluations, the software itself has proven to be interesting to faculty, who have used it, and wish to continue to use it, to develop classroom modules.

Methodology

Although the game-based methodology is not clearly preferred by all students, there is a statistically significant trend in that direction. It should also be noted that for the second year, the preference for the game-based modules seems to be highly influenced by the academic institution. In Year 2 this was suggested to be the difference between 2-year schools and 4-year schools. A similar preference effect was again confirmed in Year 3 based on institution. However, because there were two 4-year schools included in this evaluation cycle (PCT and RIT), we are able to rule out that the difference is caused by 2-year vs 4-year institutions. As shown in the data, the only trend in preference away from game-based learning came from RIT. The other 4-year school, PCT, showed a trend toward preferring the game-based methodology. At the time, this effect, therefore, is still unexplained. It is not clear if the content itself is too fundamental or if the approach is somehow not aligned with students' preferred modes of learning. Students were asked to explain their preference, and analysis of the open-ended qualitative data is ongoing.

	Other Labs	No Pref	Game-Based	Participants (N)
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Table 8. Student Preference by Institution (duplicated)

Some of the explanations for methodology preference (from RIT) are listed below, but are not exhaustive:

Students who preferred other labs or no preference (RT)

- "It's marginally less boring."
- "While I do enjoy games, and game-based labs are a nice change of pace, the interface and system of having to open other files to read information was unappealing."
- "I think this is because this lab was such a big shift in how I did labs, and also because the software was more proprietary. I might have enjoyed it more with more documentation"

Students who preferred game-based learning (RIT)

- "I felt like we were thrown in a real case with a real objective instead of just, filling out information."
- "The step by step process was much easier to follow, honestly I don't really care if it's a game or not but the instructions were clear and precise and helped every step of the way."

Content Learning

Learning the forensics content has been supported by the majority of students who used multiple tools and followed the logic of the investigation. This suggests that the methodology can help students learn. There were few students who did not report using forensic tools and few students who were not able to explain their reasoning in the case. Although preference for the game-based technique was ambivalent, the learning that occurred seemed to be clear.

Change in Interest for the field

We had made it an action item in Year 2 to further investigate a change in student interest toward the field of forensics. This year, we found that the majority of students' interest in the field changed in a positive direction, only 4% of students moving in a negative direction. This is a strong finding, and we will attempt to replicate it in next year's evaluation.