Increasing Engagement in a Network Security Management Course through Gamification

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***Abstract*—This study analyzes a gamification experience in a Network Security Management subject of an Information Technology Engineering degree to evaluate whether the spaced-education methodology contributes to the learning improvement. The gamification experience is carried out by an automatic daily delivery of technical questions to students by e-mail.**

Keywords— gamification; qstream; spaced education; network security

I. INTRODUCTION

Making education more human is related to tailored needs and multi-platform interaction, which is also a consequence of ubiquitous and distance learning.

Currently, education occurs beyond the traditional e-learning platform, creating multiple ways of interactions and generating educational data from heterogeneous sources.

Recently, games have been progressively included in everyday learning activities as a tool to engage students [1].

Proponents of educational games argue that today students are used to a different kind of interaction [2]. Students would benefit from more engaging learning material because this is how they have acquired a great deal of their cultural knowledge [3]. Many students spend long periods of time watching TV, surfing personalized content on the Internet or playing engaging games using their desktop computers or mobile phones. This fact requires a change in teaching methods or, more accurately, in learning methods [4]. Today's students find it harder to become absorbed in classroom lectures [5]. Therefore, a great deal of research effort (see games publications in Table 3) has been devoted to creating engaging games to support and promote learning [6, 7] rather than just providing enjoyment.

However, some authors claim that students do not benefit from the use of computers unless they are effective at self-regulating their learning [8]. Following this concept, Greene et al [9] analyze how students use hypermedia-learning environments to acquire knowledge of a historical topic and also historical thinking skills. They find that very often the students engage in strategy use self-regulated learning. Motivation, formative feedback and scheduled planning are important elements for self-regulated learning [9].

The influence of motivation on learning is beyond doubt, and has been a recurrent factor in the literature. In this regard, there are four major mechanisms through which motivation can affect learning, as stated by Ormrod [10]:

- It increases the level of energy and activity of the individual [11, 12].
- It drives the individuals towards certain goals, affecting their choices and their reinforcing consequences [13].
- It promotes the initiation of certain activities and that the person persists in them [14]. Motivation increases the probability of an individual starting something on their own initiative, persisting despite the difficulties and resuming the task after a temporary interruption.
- It affects the learning strategies and cognitive processes that an individual displays in a task [15].

Gibbs [16] demonstrated that feedback is an important teaching skill and is recognized as critical to effective learning. According to several authors such as Glenberg [17] or Toppino [18] online spaced education may be an effective way to improve the teaching and feedback skills on medicine learning. These studies focused on surgical residents because the methodology is independent of time and place (distributed learning).

Bjork [19] defined the term spaced education (SE) as educational programs that are constructed to take advantage of the spacing effect. This proposal is based on the psychological finding that training or educational material that is spaced and repeated over time (spaced distribution) results in greater knowledge acquisition and retention of content than when the same material is presented at a single time point (mass distribution). In such programs, material is presented in small, spaced-out nuggets, and accessed at the students' convenience; content is repeated and reinforced.

Franklin's [20] and Kerfoot's [21, 22] studies demonstrated that spaced education using e-mailed cases, questions, or short messages, can improve the acquisition and retention of topic-specific knowledge. Rider's study showed that this adaptive SE game is effective and well accepted as a method for graduate medical education [23].

This paper analyses the impact of SE, based on the Qstream tool, outside the medical teaching environment, where most of the experiences can be found. This study evaluates whether this methodology is able to contribute to the improvement of motivated, autonomous study and learning in a Network Security Management subject of the third course of an Information Technology Engineering grade.

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This study may be of interest to those researchers interested on innovative and easy procedures to accomplish ways of including gamification in their subjects.

The paper is organized as follows. Section 2 describes the experience carried out by the authors, including the methodology. Section 3 is the discussion section, which contains critical analysis of the results. Finally, section 4 provides some conclusions and highlights the future lines of work.

II. Methodology

Subject contents and competences, corresponding to the third year of Information Technology Engineering grade at UNED (Spanish University for Distance Education), present a first complete approach to the main items in the discipline. It covers the most important topics related with different kinds of attacks to the security of hosts and network devices, the most relevant security vulnerabilities, the different standards and documents related with security policies, firewalls, intrusion detection systems, security vulnerabilities scanners and principles of availability and reliability in networks. Finally it presents a complete introduction to applied cryptography, from the main algorithms (DES, AES, RSA, SHA) to complete systems, as virtual private networks and electronic commerce systems, showing the main uses of digital certificates (X.509), digital signatures and the most important cryptographic protocols, as SSL, IPSec, PGP or WEP and WPA.

The course evaluation consists on a theoretical exam. In this exam, at least 5 of the total 10 points are achieved through the correct answer of test questions related with the previously described contents. Our experience aims essentially at promoting students' performance in this specific part, although the correct knowledge acquired through QStream clearly can help to give a correct answer to the rest of the items in the exam.

The gamification experience is carried out by e-mailing technical questions to students everyday, so a ranking with the scores is created. This ranking is available and public on-line, so that any student can check his/her position. The chosen tool used in the experience was Qstream [24], which supports the delivery of the daily questions and provides quality analytics of the course and student performance in real-time. This tool has been widely used in medicine-related subjects, but not in engineering.

The methodology behind our experience is the following:

1. Teachers developed a new course in Qstream tool, based on 30 multiple choice questions with 4 possible answers each, similar to the ones in the final exam.
2. Teachers designed a survey to provide to the students at the end of the experience to know their opinion and feelings about the activity.
3. The game rules were explained to the students in the virtual course.
    a. Each student received a multiple-choice question each day by email. They could answer it from their computer, smartphone or tablet (Apple or Android).
    b. Each correct answer gave points to the student. The question was emailed again after a few days to foster knowledge assimilation. Once the student had answered correctly twice in a row, the question was not sent again because we suppose that the student already assimilated this concept.
    c. Wrong answers also scored to foster participation. However, wrong answers provided less points than correct ones. Every time a student failed a question, an educational feedback comment was provided to help him to understand his mistake. Wrong answers were sent again until students do not fail them.
    d. Students could check their score every time they answer a question and also check their peers' scores.
4. The activity in QStream was launched so that students could register and start working. The activity duration was from the beginning of the course until two weeks before the final exam (3,5 months). 36 students participated in the Qstream activity from the 49 registered in the subject.
5. An online valuation survey of the Qstream activity was submitted to the students at the end. The survey consisted of 31 questions to value the following aspects with a 6-point Likert scale:
    1. Receiving daily questions has helped me to take advantage of my time
    2. Receiving daily questions has helped me to not leaving the study to the end of the term
    3. Receiving daily questions has helped me to organize my study time more efficiently
    4. Receiving daily questions has helped me to motivate me for the study
    5. Receiving daily questions has helped me to get more interested on the subject
    6. Receiving daily questions has helped me to plan my study
    7. Receiving daily questions has helped me to be aware of my progress in the study
    8. Receiving daily questions has helped me to go more prepared to the exam
    9. Receiving daily questions has helped me to learn better the subject as a whole
    10. Receiving daily questions has helped me to consolidate what I studied
    11. Receiving daily questions has helped me to test my knowledge
    12. Receiving daily questions has helped me to review and go deeper in what I previously studied.
    13. I really enjoyed working on this activity

14. I think participating in this activity was a good opportunity
15. Everyday I was looking forward to receiving the questions
16. I think I am quite good at this activity
17. I found this activity very interesting.
18. I felt tense during the activity.
19. I think that I have performed quite well in comparison with their peers
20. I found this activity fun
21. I felt satisfied with his/her performance in the activity
22. I felt more competent to study the subject after working in this activity
23. I think that this activity is important for the understanding of the subject
24. I think that this activity has improved my study habits
25. I would like to have this activity in other subjects
26. I think that receiving points is stimulating
27. I think that comparing with my peers has helped me to improve myself
28. I found Qstream easy to use
29. I find stimulating to see the ranking everyday.
30. I think that learning through challenges is stimulating.
31. I feel prepared for the exam

6. Collection and analysis of students performance and course statistics

III. Discussion

The survey was filled by 18 out of the 36 participants in the experience. Table 1 shows the results obtained in the survey. The most valued items have been highligthed using bold styling to facilitate their identification. Figure 1 provides a graphical representation of Table 1.

As table 1 shows, survey results were extremely positives. The data analysis regarding the motivation of the students indicates that, in general, the participants would like to have this activity in other subjects and really enjoyed working on this activity, found it easy to use, fun and very interesting. All participants also think that receiving daily questions has helped them to test their knowledge, review and go deeper in what they previously studied. Students also think that this gamification experience has helped them to be more motivated for the study and interested on the subject. They were looking forward to receiving the questions everyday and think that receiving points and learning through challenges is stimulating. They also found stimulating to see the ranking everyday. This kind of methodology didn't make them feel tense or pressured, but helped them to be more aware of their progress in the study.

Regarding self-organization for the study, results are also very positive. Most of the students think that receiving daily questions has helped them to plan better the study, not leaving it to the end of the term and organize their study time more efficiently taking more advantage of it. Most students also think that this activity has improved their study habits and helped them to improve themselves.

Questions	0	1	2	3	4	5
Q1.	6%	11%	6%	17%	44%	17%
Q2.	0%	0%	6%	28%	17%	50%
Q3.	6%	6%	11%	28%	22%	28%
Q4.	0%	0%	0%	6%	44%	50%
Q5.	11%	0%	0%	6%	39%	44%
Q6.	6%	11%	11%	28%	22%	22%
Q7.	0%	11%	6%	22%	22%	39%
Q8.	0%	6%	11%	6%	33%	44%
Q9.	0%	6%	6%	22%	33%	33%
Q10.	0%	0%	0%	22%	33%	44%
Q11.	0%	0%	0%	17%	22%	61%
Q12.	0%	6%	6%	11%	28%	50%
Q13.	0%	0%	0%	17%	17%	67%
Q14.	0%	0%	11%	17%	22%	50%
Q15.	6%	6%	0%	22%	28%	39%
Q16.	0%	6%	6%	39%	39%	11%
Q17.	0%	0%	0%	11%	28%	61%
Q18.	50%	0%	22%	11%	17%	0%
Q19.	6%	6%	11%	56%	17%	6%
Q20.	0%	0%	0%	17%	22%	61%
Q21.	0%	6%	6%	22%	39%	28%
Q22.	0%	6%	17%	28%	28%	22%
Q23.	0%	6%	22%	11%	22%	39%
Q24.	0%	0%	39%	28%	22%	11%
Q25.	0%	0%	0%	11%	11%	78%
Q26.	0%	6	6%	17%	17%	56%
Q27.	6%	6%	0%	22%	11%	56%
Q28.	0%	0%	0%	0%	33%	67%
Q29.	11%	0%	6%	11%	33%	39%
Q30.	0%	0%	6%	22%	28%	44%
Q31.	0%	0%	7%	39%	56%	6%

Table 1. Results of the survey valued following a 6-point Likert scale, meaining 0: Extremely dissatisfied and 6 Extremely satisfied. N=18.

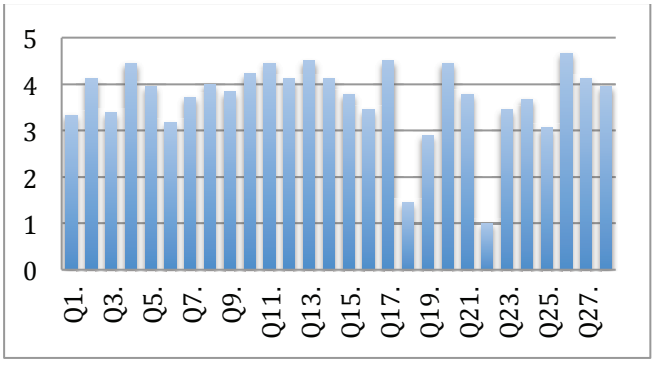

Fig. 1. Graphical representation of survey.

Finally, regarding the learning improvement perception, results show that students mostly think that this activity has helped them to consolidate what they studied, feel more competent to study the subject and learn better the subject as a whole. In general, thanks to this activity they go more prepared to the exam and understand better the subject.

IV. Conclusions

In this first experience with the QStream tool, we analyzed the opinion of the students in terms related with different pedagogical aspects, as the organization of the studying of the contents of the subject, the motivation, the preparation of the final exam, the performance as seen by the student, the didactical effects of a real competition with their peers and a number of other criteria.

As conclusions, the main finding obtained from this study is that the spaced education methodology through the QStream tool seems to bring also important benefits in the field of network security management education, not only to medicine where it was proved to be useful. Among the benefits of using this methodology we find improvements on self-study organization, motivation and learning acquisition.

The global results were promising, challenging us to repeat the experience, applying the methodology to other subjects and areas.

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