Gamification Of Physics Education: Using Extrinsic Gaming Motivators to Improve Learning Outcomes in a First Year Undergraduate Course

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Introduction

Purpose

- To rigorously test the benefits of game-based learning in education
- To attempt to improve student motivation
- To attempt to improve student enjoyment of their course material

Design

- Two types of Quizzes, list-style (traditional) and gamified-style

List Style	Gamified Style
All questions available simultaneous	Questions are given one question at a time
A correct response gives a student a mark	A correct response gives a student points
The value of a question is fixed	The points received for a correct response depends on streaks
Final grade presented as *Number of correct responses/Total Number of questions*	Final grade presented as Total score
A passing mark is 60%	A passing mark is set to be of equivalent difficulty to 60%

Design

The Gamified Quiz

$$K * \frac{c-1+n}{c} * N$$

Quiz Number	Number of Questions	c	K	Points To Pass	Points Needed for One Star	Points Needed for Two Stars	Points Needed for Three Stars
Quiz 1	19	10	20	1656	2382	4402	8360
Quiz 2	6	2	150	1650	2100	4200	8400
Quiz 3	15	5	25	1245	2075	3705	8600
Quiz 4	11	8	55	1683	2310	4675	8470

n number of correct responses answered consecutively

N number of correct responses total so far

c Determines the weight of the streaks

K Normalizes the points

Design

The Gamified Quiz

- Additional Gamified Elements
  - Students can earn up to three stars, depending on the number of points received
  - Instant feedback given after each response
  - Leaderboards and badges were implement in the second term

Change Password

Logout

The GOPE

Physics 1070: Introductory Physics for Life Sciences

Pre-test 1 *(Passed)* Get Receipt

Pre-test 2 *(Passed)* Get Receipt

Pre-test 3 *(Passed)* Get Receipt

Pre-test 4 *(Passed)* Get Receipt

All Star
Students with this badge: 1

Rising Star
Students with this badge: 9

Speedster
Students with this badge: 5

Over Achiever
Students with this badge: 0

Welcome to the Gamification of Physics Education (GOPE) Gaming Platform

Thank you for volunteering to be a part of our efforts to develop new innovative and engaging physics education methods for our students. In particular, these pretests begin an effort to utilize elements of gaming in undergraduate physics.

While the content and the concepts assessed remain the same as for our traditional pretests, these pretests function differently than those you may be used to. Here is a brief overview of what to expect:

- You will be awarded points for a correct answer, rather than just a "yes/no" mark
- The more questions you answer correctly, the more points each subsequent question is worth
- The more questions you answer correctly consecutively i.e. in a row, the more points each subsequent question is worth
- As is the case with the traditional pretests, you must score a minimum number of points to pass the quiz
- Stars are not a requirement to gain access to the quiz room and will have no effect on your grade. However, they are meant as a source of motivation for students.
- When you have successfully completed your pretest you will receive a receipt which you must print and bring to the quiz room as proof
- Hover your mouse over the various components in the quiz for an explanation as to what they mean

Please send any feedback or issues to jrose07@uoguelph.ca

1/6

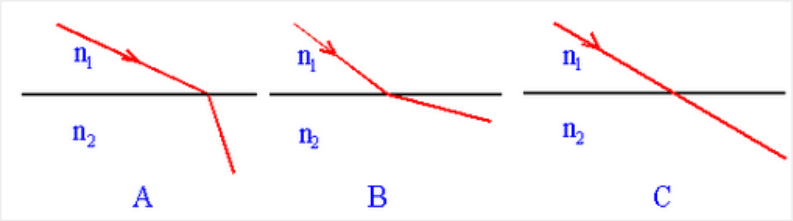
★★★2100 ★★★4200 ★★★8400

Your Score: 0 / 1650

150

Pass

Two transparent fluids are in contact at a plane interface. A ray of light is incident on the interface. Which drawing below is correct if $n_1 > n_2$?



C

B

A

Lock In Answer

The GOPE

End Quiz

2/6

★★★2100 ★★★4200 ★★★8400

Your Score: 150 / 1650

450

Pass

One of the statements below is

The myopic eye has a to for the distance from cornea to retina

Good!

The distance from the c is too large for the total power of the refracting surface in the eye.

The astigmatic eye has a cornea with a different curvature in different directions.

Lock In Answer

Please send any feedback or issues to jrose07@uoguelph.ca

End Quiz

The GOPE

2/6

★★★2100 ★★★4200 ★★★8400

Your Score: 150 / 1650

450

Pass

One of the statements below is incorrect; which one?

- The myopic eye has a total power of its refracting surfaces too large for the distance from cornea to retina
- The distance from the cornea to the retina in the hypermetropic eye is too large for the total power of the refracting surface in the eye.
- The astigmatic eye has a cornea with a different curvature in different directions.

Lock In Answer

Please send any feedback or issues to jrose07@uoguelph.ca

End Quiz

The GOPE

3/6

★★★2100 ★★★4200 ★★★8400

Your Score: 150 / 1650

300

Pass

One of the statements below is incorrect. Which one?

Snell's law is: $n_1 \sin \theta_1 =$

Incorrect

The angle of reflection =

n = c/v, where n is the in in the medium, and c is the speed of light in a vacuum.

The angle of reflection = The angle of incidence

Lock In Answer

Please send any feedback or issues to jrose07@uoguelph.ca

The GOPE

End Quiz

4/6

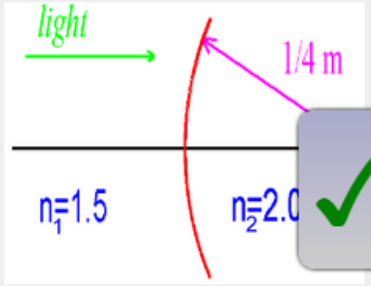
★★★2100 ★★★4200 ★★★8400

Your Score: 450 / 1650

675

Pass

The power of this surface is:



Brilliant!

-1

-2

1

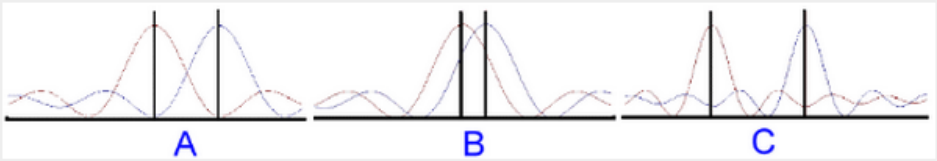
2

Lock In Answer

Please send any feedback or issues to jroseo7@uoguelph.ca

The GOPE

Question 1: The drawings show the intensity profile of the diffraction patterns of two small sources of light, after the light has passed through a small circular aperture.



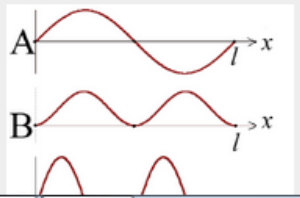
In which case are the two images just on the verge of being resolved?

- C
- B
- A

Question 2: Given below are several formulas relating energy (E), frequency (f), angular frequency (w), wave vector (k) along with Planck's constant (h) and the speed of light (c) for an EM wave (or photon). One of them is incorrect; which one?

- $E = hck/2\pi$
- $E = hc/\lambda$
- $c = f/\lambda$
- $E = hf$
- $E = h\omega/2\pi$

Question 3: Below are 4 graphs as a function of distance x. Which one represents the probability density P as a function of position along a π-bonded linear molecule of length *l* for an electron in the n = 2 state.



Method

Courselink	List-Style	Gamified
Course Website	TheGope.com	TheGope.com
Already Established	Developed for This Study	Developed for This Study
Old Graphics	New, Updated Graphics	New, Updated Graphics
List-Style Quizzes	List-Style Quizzes	Gamified Quizzes
Control Group	Control Group	Test Group

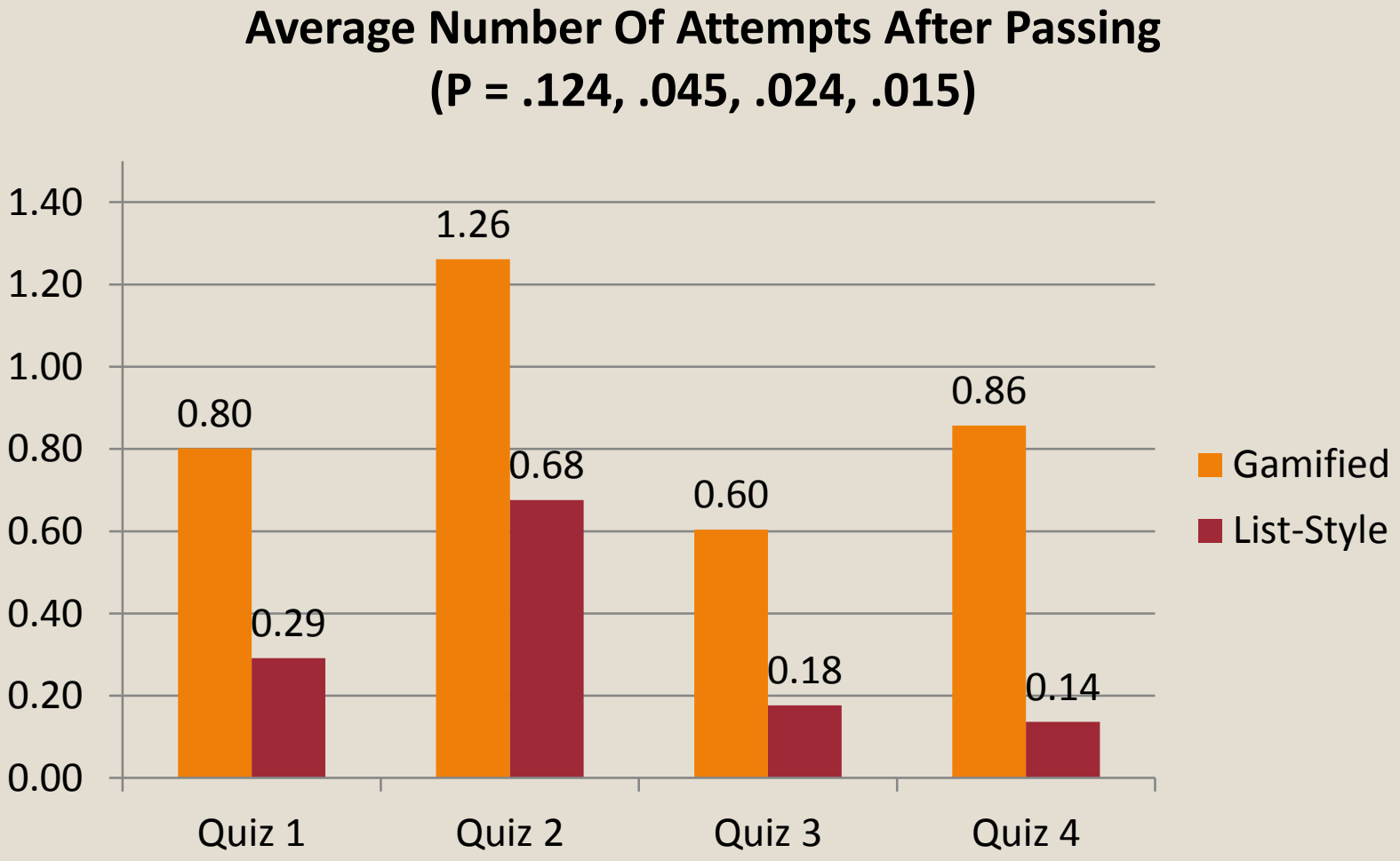
Method

- Students required to write pre-tests
- Pre-tests given to students not worth grades
- Students are required to pass a minimum threshold in order to get into the quiz room
- No difference to students final grade once student minimum threshold
- List style quizzes, threshold at 60%. For gamified, points adjusted for similar difficulty

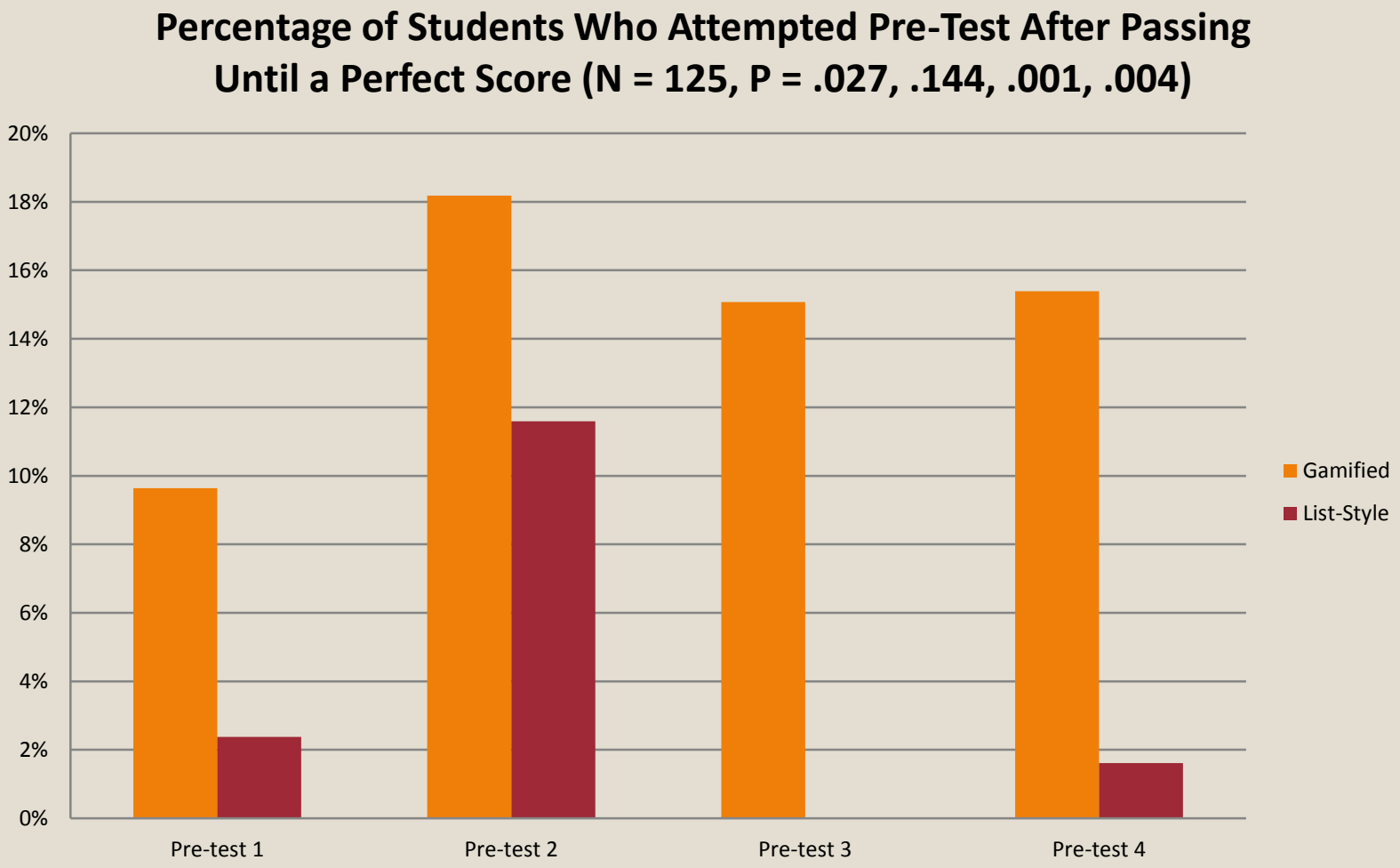
Method

- Once a student achieves the minimum threshold, very little course-based extrinsic motivators remain
- The number of attempts after the passing attempt was measured motivation
- The percentage of students in each group who made attempts after passing until they achieved perfect was measured
- Finally, all students completed a survey at the end of the term

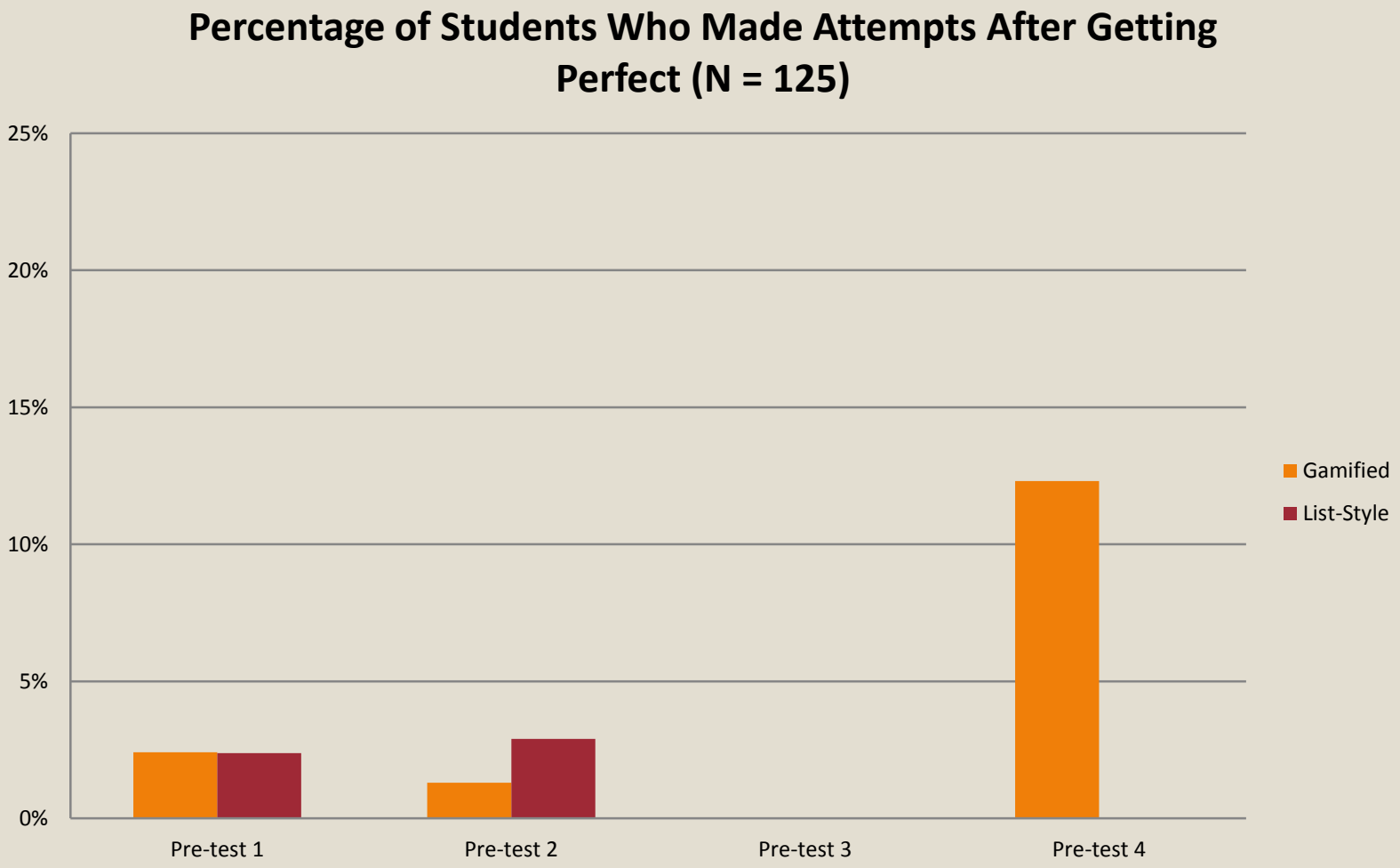
Results


Average Number Of Attempts After Passing
(P = .124, .045, .024, .015)
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0.80
0.29
1.26
0.68
0.60
0.18
0.86
0.14
Quiz 1
Quiz 2
Quiz 3
Quiz 4
Gamified
List-Style

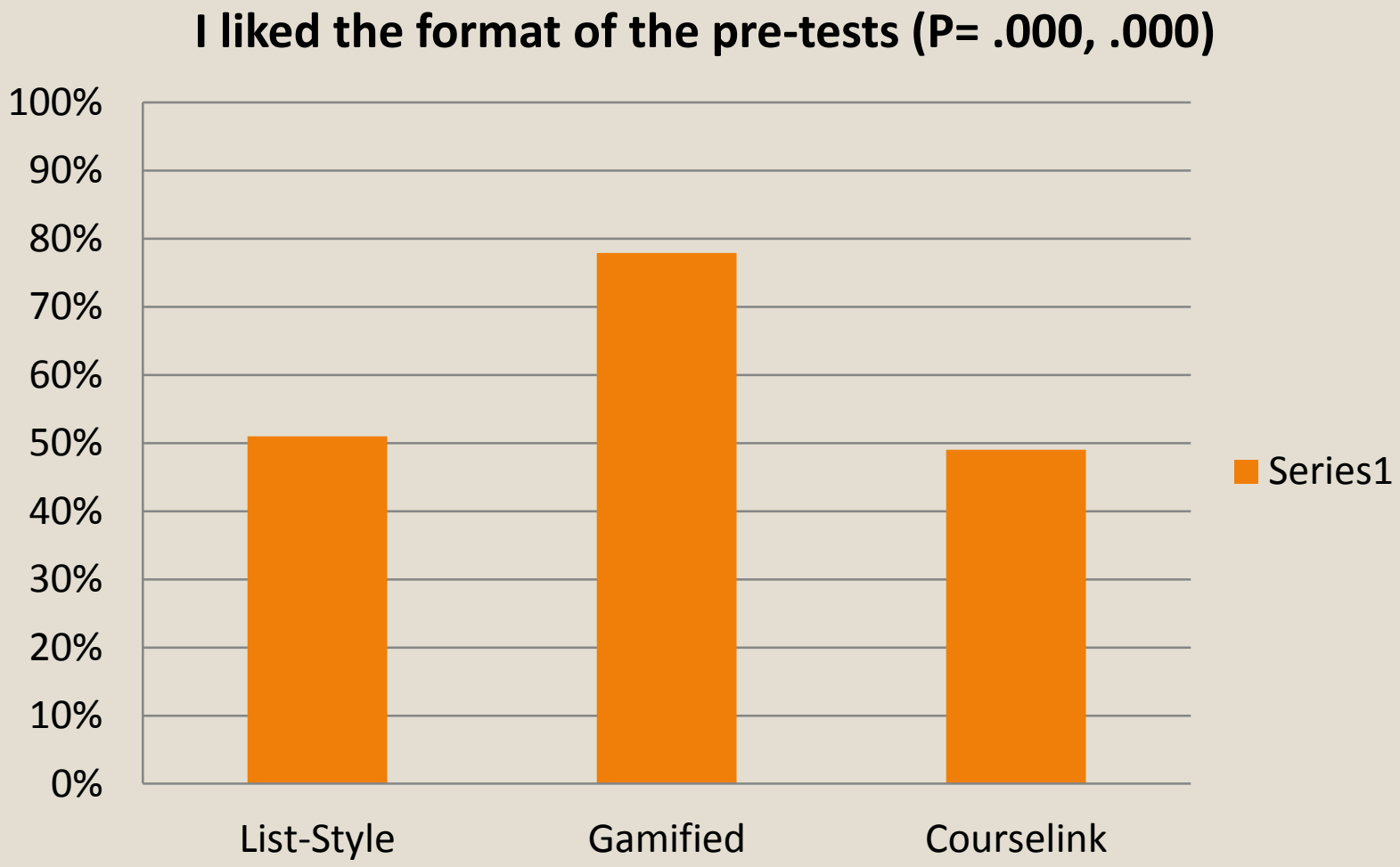
Results


Percentage of Students Who Attempted Pre-Test After Passing Until a Perfect Score (N = 125, P = .027, .144, .001, .004)
20%
18%
16%
14%
12%
10%
8%
6%
4%
2%
0%
Pre-test 1
Pre-test 2
Pre-test 3
Pre-test 4
Gamified
List-Style

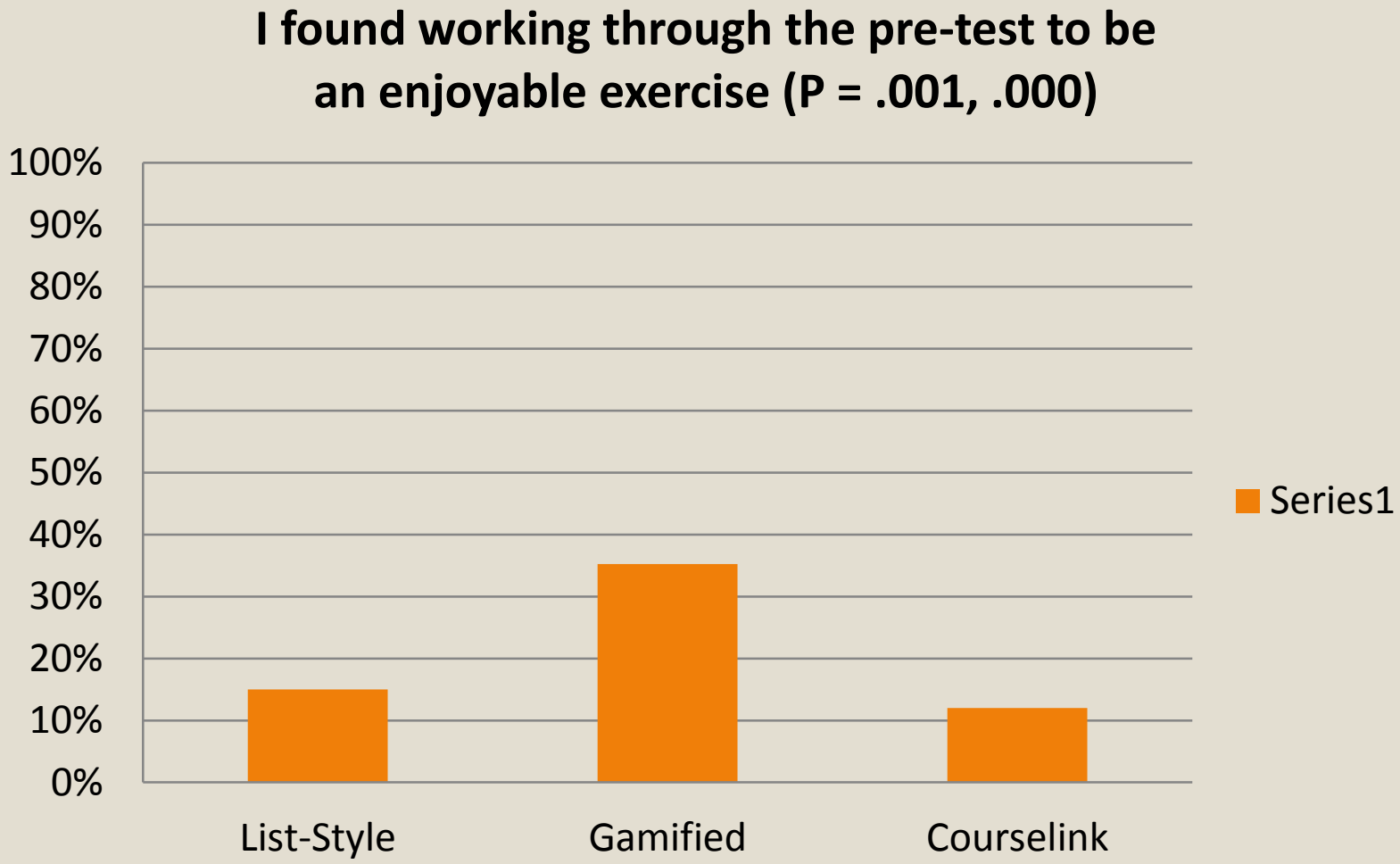
Results


Percentage of Students Who Made Attempts After Getting Perfect (N = 125)
25%
20%
15%
10%
5%
0%
Pre-test 1
Pre-test 2
Pre-test 3
Pre-test 4
Gamified
List-Style

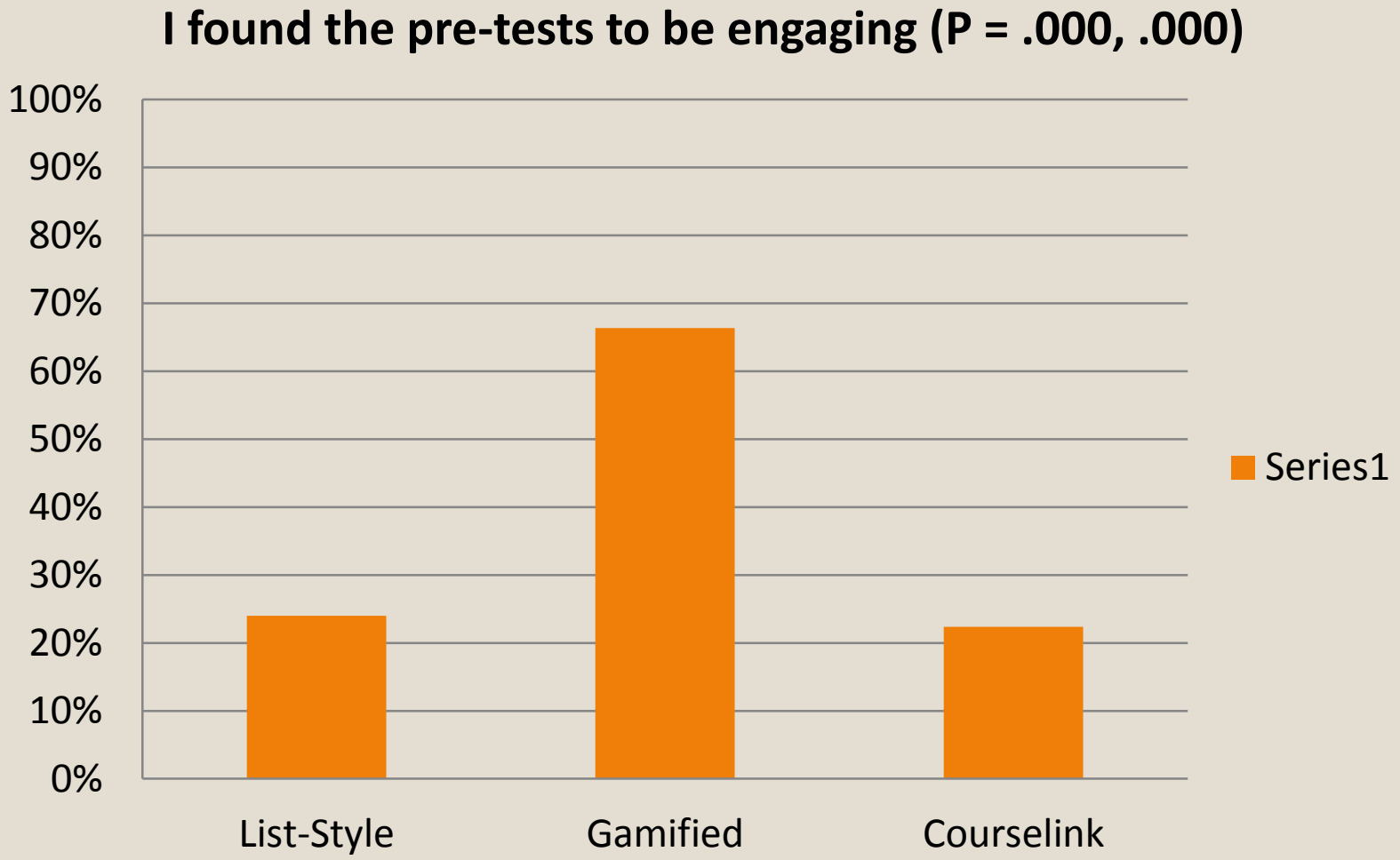
Survey Results (N= 361)



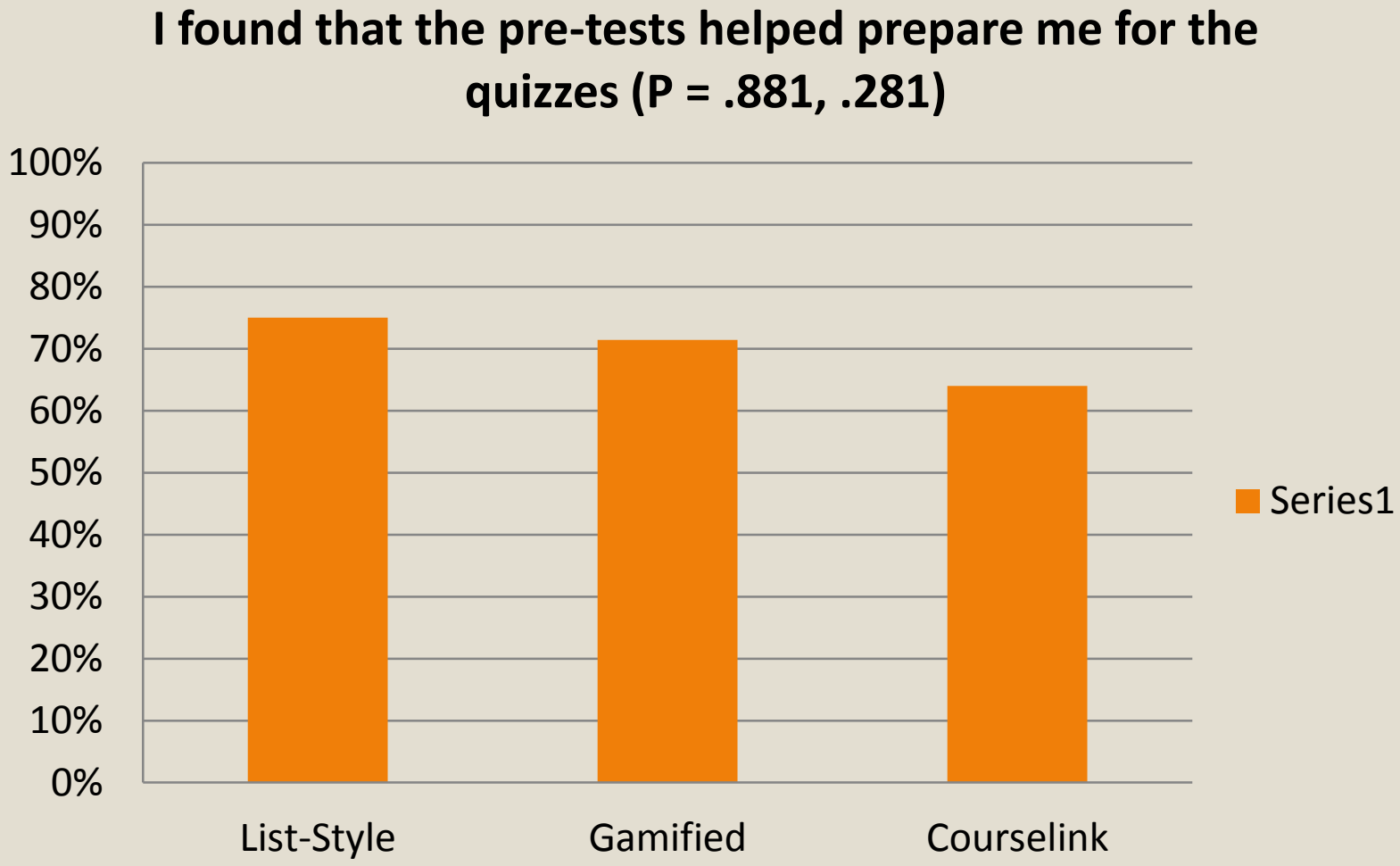
Survey Results (N= 361)



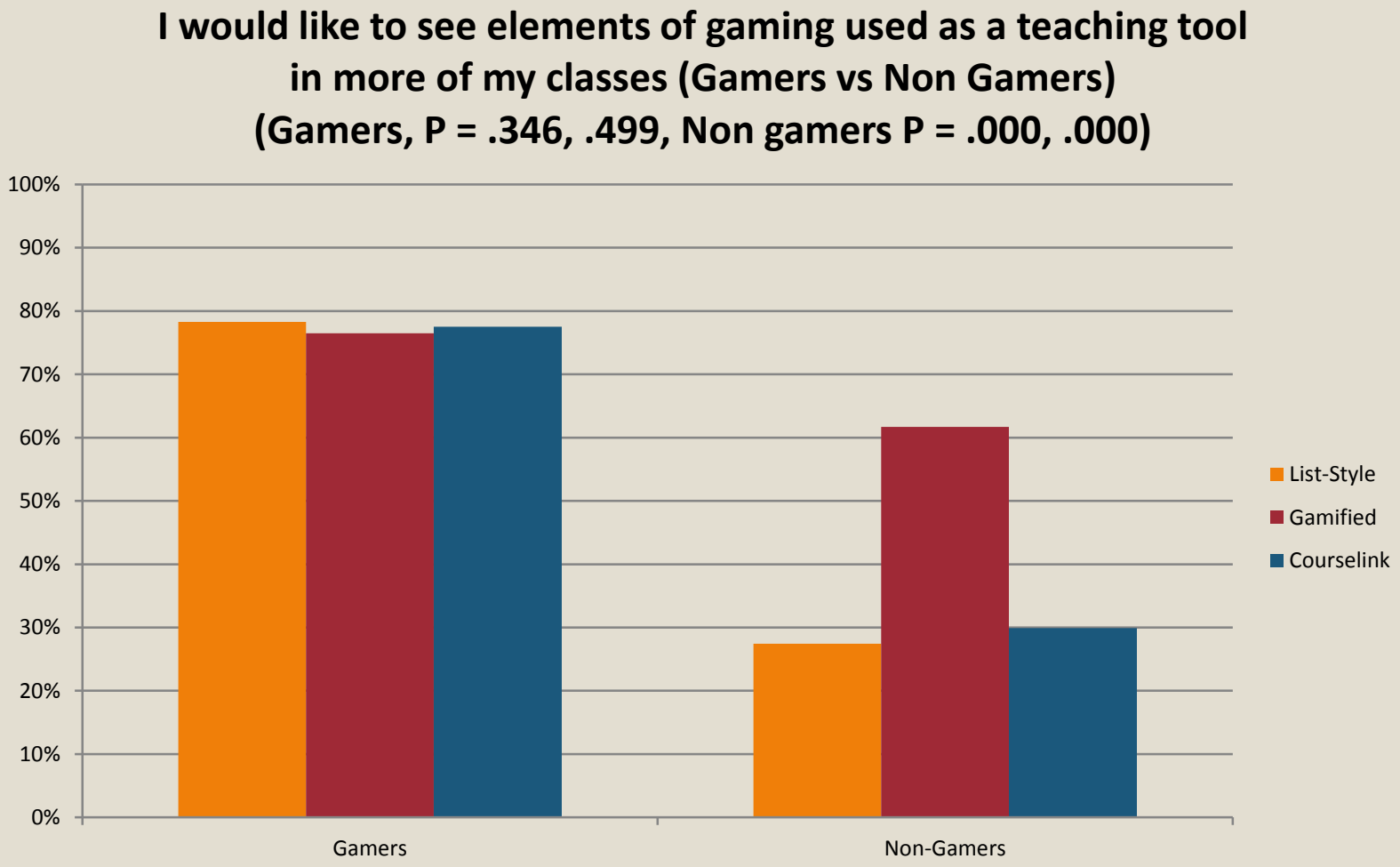
Survey Results (N= 361)



Survey Results (N= 361)



Survey Results (N= 361)



Conclusions

- Higher levels of motivation are observed for students taking Gamified Pre-tests
- A large fraction of students are motivated by the extrinsic reward of stars
- Overall, students find the Gamified pre-tests more engaging, enjoyable, and they like the format better
- Students who have experience with gaming or gamification want more gamification
- Students who do not consider themselves gamers do not see the need for more gamification, until they experience it

Further Research

- Would higher levels of difficulty maintain high levels of motivation?
- Can we exaggerate these results with other techniques (e.g. avatars, fantasy gaming elements, stories, etc)
- How much does class exposure effect results?
- Remove students ability to take other groups quizzes

Acknowledgements

- Boom Digital Media group developed The GOPE website and gaming platform