THE THRESHOLD CONCEPTS IN THE THREE MAIN PHYSICS COURSES OF THE CEGEP SCIENCE PROGRAM

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ABSTRACT

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In this study, the threshold concepts of the three CEGEP-level physics courses of the Science Program were identified by physics teachers. The result showed that, while NYA and NYB have more threshold concepts than NYC, there is no significant difference in the number of threshold concepts in NYA and NYB. Threshold concepts can form roadblocks to student success and persistence. Identifying them is a critical exercise ahead of implementing the newly revised Science Program.

Keywords: Threshold Concepts, Physics Courses, Science Program Revision

INTRODUCTION

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Threshold concepts are possible roadblocks that are capable of derailing the learning process. They can be integrative, troublesome, act as a one-way portal, and irreversibly transform how students think (Meyer, 2010). Continued use of alternative conceptions, inability to make links between concepts, difficulty learning other concepts (Psycharis, 2016), reliance on the surface approach (Flanagan et al., 2010), and disengagement (Davies, 2006) are possible consequences of not mastering a threshold.

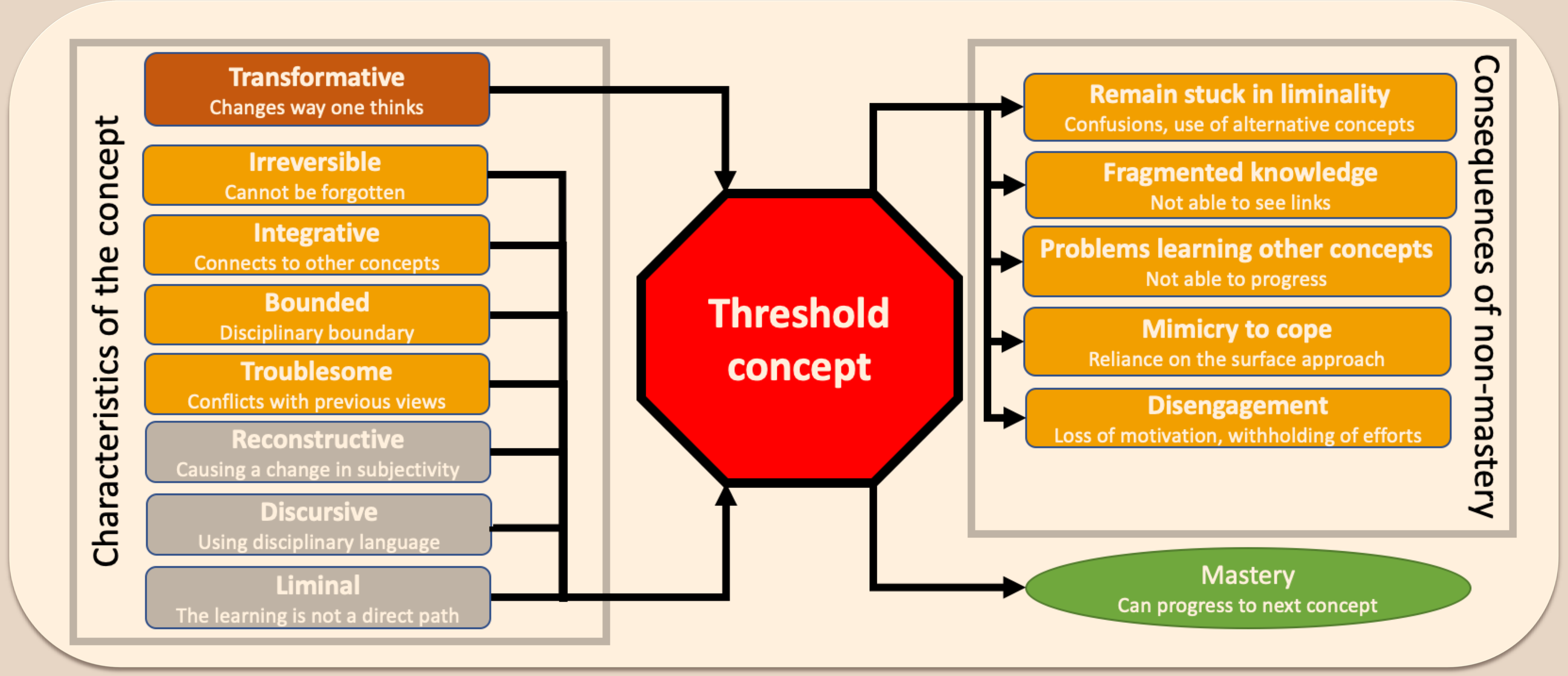

Figure 1: Characteristics and consequences of non-mastery associated with threshold concepts

More on threshold concepts

BACKGROUND

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Mechanics (NYA) is more challenging than other physics courses. As shown by diagnostic tests (the force concept inventory), for many students, taking the Mechanics course does not result in a significant gain in understanding key concepts (Lasry et al., 2014). An accumulation of threshold concepts might be a possible explanation why students struggle more in some courses than in others.

This qualitative study aimed to answer two research questions: First, what are the threshold concepts in those courses, and second, does NYA have a significantly higher number of threshold concepts than the other two courses studied?

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METHOD

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The physics teachers (14-16, depending on the round) at a college, used a Delphi process to create a list of threshold concepts for these courses. The criteria for being considered a threshold concept was that the concept had to be a) transformative and b) have at least one other characteristic or consequence usually associated with threshold concepts. Being reconstructive, discursive, and liminal have not been used in the study. After the Delphi process, another survey evaluated the usefulness of the process and the results.

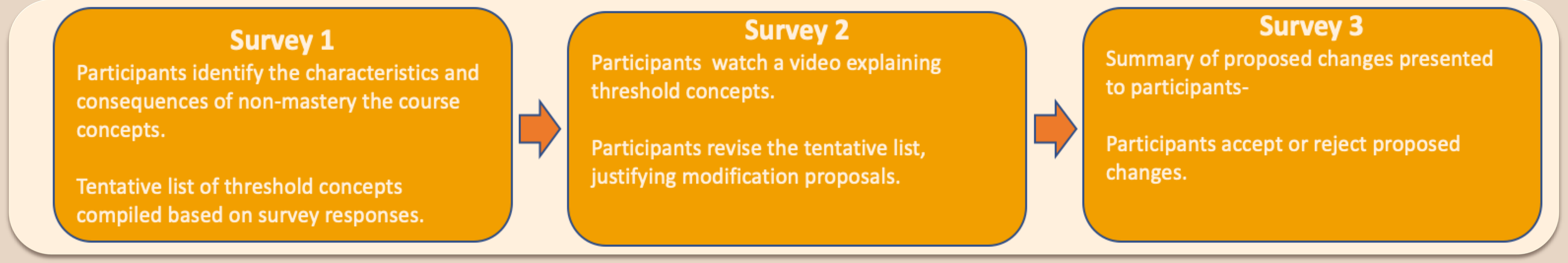

Figure 2: Details of the Delphi process

RESULTS

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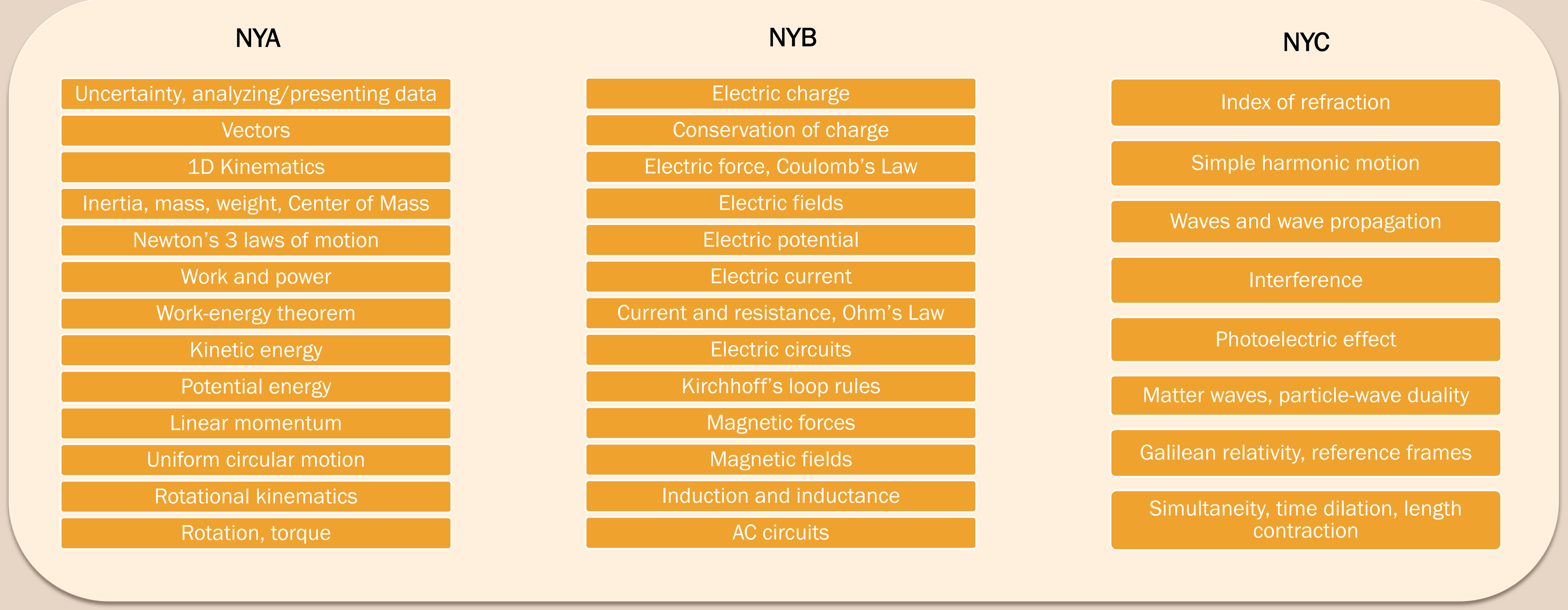

NYA	NYB	NYC
Uncertainty, analyzing/presenting data	Electric charge	Index of refraction
Vectors	Conservation of charge	Simple harmonic motion
1D Kinematics	Electric force, Coulomb's Law	Waves and wave propagation
Inertia, mass, weight, Center of Mass	Electric fields	Interference
Newton's 3 laws of motion	Electric potential	Photoelectric effect
Work and power	Electric current	Matter waves, particle-wave duality
Work-energy theorem	Current and resistance, Ohm's Law	Galilean relativity, reference frames
Kinetic energy	Electric circuits	Simultaneity, time dilation, length contraction
Potential energy	Kirchhoff's loop rules	
Linear momentum	Magnetic forces	
Uniform circular motion	Magnetic fields	
Rotational kinematics	Induction and inductance	
Rotation, torque	AC circuits	

Figure 3: List of threshold concepts identified for Mechanics (NYA), Electricity & Magnetism (NYB), and Waves & Modern Physics (NYC)

The process and the resulting list have been considered useful or somewhat useful by most participants. Some suggest doing it face-to-face instead of using anonymous surveys.

CONCLUSIONS

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Threshold concepts need special consideration when revising the Science Program curriculum, a process currently underway in the Quebec CEGEP system. But even if no changes are made to the learning sequence, raising awareness of their presence will help teachers better understand student difficulties and improve their teaching.

Our study highlights that an investigation of the number and nature of threshold concepts in Electricity & Magnetism and other domains of the Science Program warrants further investigation. Given the benefits of identifying the thresholds, it would be interesting to repeat the process at other colleges.

RESEARCH ETHICS APPROVAL This project has obtained approval for a year from the participating College's research ethics board on September 17th, 2020.