Full Paper: Implement Hands-on Activities for Statics Course into Student Success Programs

1. Background

The University of Wisconsin-Platteville (UWP) is a very much student-centered teaching school with high reputation for its engineering programs. The College of Engineering, Mathematics and Science **Student Success Programs** (EMS SSP) plays a crucial role in helping students become the next generation of successful engineers.

In EMS SSP, there are three **Living Learning Communities (LLCs)** for students pursing a degree in STEM fields. In 2017, the UWP is proud to offer an **Explore EMS LLC** for all freshman students in the College of EMS who are interested in exploring career opportunities in EMS fields. The **Women in STEM LLC** has two options available, one for incoming freshmen and one for sophomore and transfer students. More than half of the students who are in the freshman LLC choose to continue on to the sophomore LLC. To date, members of the LLC have retained at a rate of 84% (freshmen) (Fig. 1) and 92% (sophomore and transfer) (Fig. 2).
By comparison, the average first-to-second year retention rate for all students in the College of EMS is 76.8%.

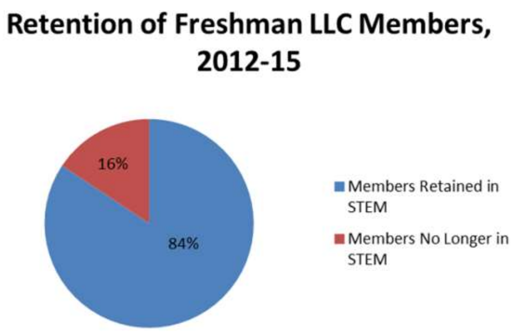

Fig. 1: Retention of Freshman LLC Member (2012-2013)

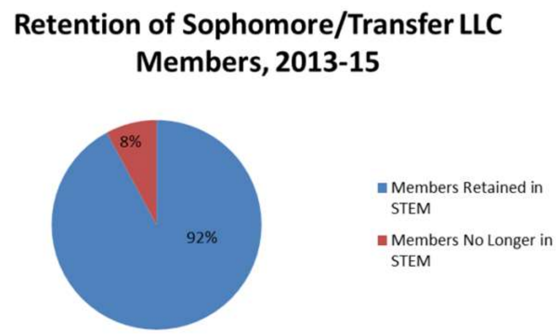

Fig. 2: Retention of Sophomore/Transfer LLC Member (2013-2015)

In this proposed project, the first author will work with a team who are involved with the EMS Student Suceess Programs, Residence Life, and Academic Support Programs to create an academic cohort experience for first-year engineering students. Our role will focus on integrating some fundamental engineering hands-on activities related to engineering statics course content into these three LLCs.

2. Implement hands-on activities into LLCs

LLCs are a high-impact practice where first-year students are placed in a common living area and are connected by major or interest. LLCs are receiving considerable attention by higher education scholars and practitioners [1-10]. As described by Gablenick, MacGregor, Matthews, and Smith in their book Learning Communities [1]: Creating Connections Among Students, Faculty, and Disciplines, faculty who are teaching the common courses got involved with the LLC strengthen the social and intellectual connections between students and faculty.

2.1 Statics course

Statics is the first in the Mechanics sequence and is highly concept-heavy course. It is an essential prerequisite for many branches of engineering, such as mechanical, civil, aeronautical, and biomedical engineering, which addresses the various consequences of forces. Retention is especially important during the first two years in any engineering program while many students are still in transition and not quite sure if engineering is the right career choice for them. It is imperative that faculty teaching first and second year engineering courses continue to strive to retain and engage students and help them succeed in their engineering course of study. The introduction of hands-on activities has always been a mechanism to increase student interest and engagement.

2.2 Action plan

In a recent project we have developed and implemented some hands-on activities in "Women in STEM LLC". We have planned five hands-on activities (Table 1) based on statics concepts and implemented one activity of how to visualize two forces and three forces in equilibrium using the "Parallelogram Law" into this project.

Using the kits acquired students will work with a set of experiments in a small group with 5 or 6 students. These activities will relate to the Statics course students are going to study later.

Table 1: Hands-on activities

Activity	Description
1	Hooke's Law—Measuring Force
2	Adding Forces—Resultants and Equilibriants
3	Resolving Forces—Components
4	Center of Mass
5	Sliding Friction

On March 13, we organized one activity titled "What is Equilibrium and how to visualize it" at the Women in STEM LLC. There are total 25 students assigned for this activity and we arranged four groups to work on this activity.

In this activity, we deomonstrated two different equilibrium problems: two forces in equilibrium (Fig. 3) and three forces in equilibrium (Fig. 4).

2.2.1 Two forces in equilibrium

2.2.1.1 Set up

a. Set up the Spring Scale and Force Wheel on the Statics Board as shown. Twist the Force Wheel until the bubble level shows that the Force Wheel is level. Attach one of the threads from the force disk (inner part of the String Tie) in the center of the Force Wheel to the bottom hook of the Spring Scale. Connect a second thread to a mass hanger (let the third thread dangle). Add 80 g (0.080 kg) to the mass hanger.
b. Adjust the Spring Scale up or down so that the force disk is centered in the Force Wheel. The mass hanger applies a force downward, $F_g = mg$ (the force due to gravity, where m is the total mass of the mass hanger). When the force disk is centered, the system is in equilibrium, so the downward force F_g must be balanced by an equal and opposite force, the equilibriant, F_E. In this case, the equilibriant force, F_E, is applied by the Spring Scale.

2.2.1.2 Check the two forces in equilibrium

a. What are the magnitude and direction of F_g, the gravitational force applied by the hanger, where $F_g = mg$?

• F_g: Magnitude ________0.78 N_________ Direction ________________

b. Use the Spring Scale and Force Wheel to determine the magnitude and direction of F_E, the equilibriant.

• F_E: Magnitude ________0.8________ Direction ________________

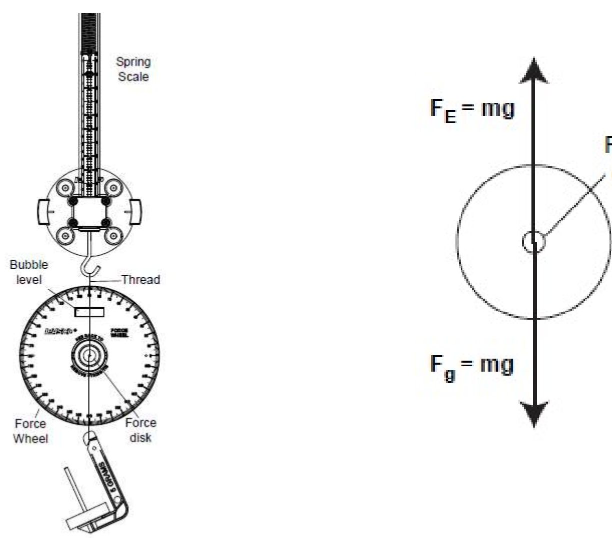

Fig. 3: Demonstration of two forces in equilibrium

2.2.2 Three forces in equilibrium

2.2.2.1 Set up

a. Attach the Large Pulley and the two Small Pulleys to the Statics Board and move the Spring Scale as shown in the figure.
b. Attach threads to the bottom hook of the Spring Scale and to mass hangers over the Small Pulleys.
c. Add 30 g (0.030 kg) to the upper mass hanger and add 50 g (0.050 kg) to the lower mass hanger.
d. Adjust the Large Pulley and the Spring Scale so that the force disk is centered in the Force Wheel.
e. How much can you change the mass on the hangers and still leave the force disk centered in the Force Wheel?

2.2.2.2 Collect the data

Record the values of the hanging masses M_1 and M_2 (including the mass of the mass hangers), the magnitude in newtons of the forces F_1, F_2, and F_E, and the angles θ_1, θ_2, and θ_E with respect to the zero-degree line on the Force Wheel.

Table 2: Data for three forces in equilibrium

Mass (kg)		**Force (N)**		**Angle (°)**	
M_1	0.03	F_1	0.29	θ_1	33°
M_2	0.05	F_2	0.49	θ_2	-36^0
		F_E	0.68	θ_E	168^0

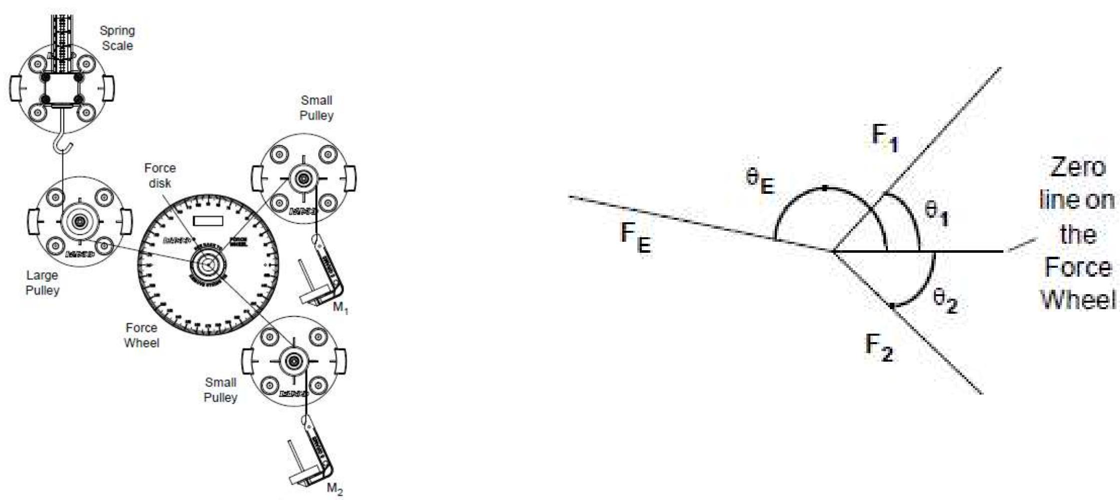

Fig. 4: Demonstration of three forces in equilibrium

2.3 Discussion

After this activity, we did survey with 5 questions and we received total 25 students' feedback. The results were shown in Table 3.

Table 3: Survey Questions (Spring 2019)

Questions	Results from students		
	Yes	No	Has not taken statics
1. Did you find this activity interesting?	24	1	
2. Did this activity help in your understanding of the related concepts from our statics class?	6	2	17
3. Did you have any difficulty with the activity?	20	5	
4. Would more hands-on activities of this type be of any benefit in this course?	24	1	
5. Was the size of the group	Just right	Too big	Too small
	19	6	

In Table 2, it showed 96% of students finding this activity interesting and 68% of students have not taken statics course to recognize this activity help in their understanding of the related concepts from our statics class. It indicated that by providing more hands-on activities into LLCs, we potentially can attarct more students into engineering programs. The results from Table 2 also indicated that 80% of students did this activity without any difficult and 96% of the students agreed that more hands-on activities of this type be of any benefit in this course. Regarding to the size of the group, 24% of the students think the size of the group is too big. Since there are only 4 equimpents for this activity, there is about 6 students for each group. For better get involved with this activiey, the better size for each group is about 2 to 3 students. In the future, we will consider and organize small groups for these activities to make sure each student can better engage with these activities.

From this hands-on activity, it did help students to better understand the concept of equilibrium and visualize the two and three forces in equilibrium. Among all these 25 students, there are some freshman and they did have difficulties to understand three forces at equilibrium. Our experience from the past semester suggested that adding such hands-on activities to the teaching of fundamental engineering concepts has a very high potential of improving the understanding of basic concepts.

3. Outcomes

Through these hands-on active engagements, we hope we can achieve these following goals:

1) Provide a bridge between the formal academic program and out-of-classroom learning for students.
2) Promote personal and intellectual growth and development of students through contact with members of the faculty.
3) Provide a transition between classroom and residence hall life leading to higher student retention, satisfaction, and success.
4) Provide collaboration opportunities between students and faculty.

Besides the survey questions we did from this activity and we will continue this activity in the future and expect to see some positive results for student retention, performance and selection of major . Also there are several other criteria we would like to evaluate as outcomes between LLC students and Non-LLC students in the future project.

Reference:

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