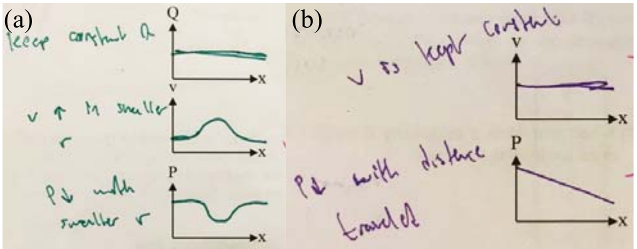

FIG 5. (a) Correct depiction of flow rate, speed, and pressure of ideal fluid through a restriction. (b) Incorrect depiction of speed and partially correct depiction of pressure of a real fluid through a restriction. (Both depictions were made by the same student.)

2. Open-ended Post-test Results

The purpose of group 3 students was to help refine the preliminary assessment through open-ended responses. Small instructional deviations were made to include the idea of fluid resistance before introducing the KCSM. The students were then guided to make in-class predictions of the fluid speed and pressure versus position using the KCSM. The requested predictions were similar in concept to Q4 and Q5 of the multiple-choice assessment. Even with the introduction to fluid resistance, the group 3 students still made graphical predictions assuming ideal fluid behavior, meaning students made little to no connection between fluid resistance and pressure.

Group 3 students made similar whiteboard predictions regarding speed and pressure versus position as those of groups 1 & 2 (Fig. 3). About 50% of students accurately predicted the speed versus position profile. The common mistake in inaccurate fluid speed predictions based on continuity was neglecting the combined cross-sectional area of the capillaries compared to the aorta which was confirmed by demonstration of the KCSM. Again, the group 3 students made consistent, but still inaccurate, predictions of pressure based on BP response to fluid speed. The importance of fluid resistance was then demonstrated through observation of real-time pressure data (Fig. 2).

The post-test for group 3 involved a written assessment that included open-ended versions of the five multiple-choice questions analyzed for groups 1 & 2. Overall trends for all three groups were the same. That is, the KCSM appeared to be very successful in clarifying the concepts of conservation of mass and BP (Fig. 4: Q1,2,4 equivalent to Fig. 5a). However, the understanding of the difference between ideal and viscous fluids was less successful (Fig. 4: Q3,5 equivalent to Fig 5b).

V. CONCLUSIONS

The improvements in understanding the effect of viscosity with respect to HPP (Gains on Q3,5) were small. This is problematic because fluid resistance plays the dominant role in pressure drop across the circulatory system. The assessment results suggests the need for a modification in the instructional design, such as an experiment that demonstrates the variables described in Eq. 3, to improve students' conceptual understanding of HPP.

Curiously, the similarity of assessment results between the two groups suggests that it makes no difference if the KCSM is taught alone in physics or in parallel with A&P courses. In the future we plan to use an attitude survey to compare how the students feel about the content either looking at it solely in physics or in parallel with anatomy and physiology.

Our preliminary assessment results indicate that the KCSM helps students to develop a more holistic understanding of both important physics fluid principles, as well as the physiology of the circulatory system. The enhanced understanding can also be applied to other systems of the human body, such as the respiratory system, allowing students to use their physics knowledge in other units of their A&P courses. This is consistent with the recommendations that all biology students have a comprehensive knowledge base of fluid dynamics principles [11]. Future efforts will also include improving the preliminary assessment by incorporating student generated open-ended distractors into the conceptual fluid dynamics survey and to compare the model efficacy by deploying the assessment in more traditional physics lecture-lab environments without the use of the KCSM.

VI. ACKNOWLEDGEMENTS

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