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## A Worksheet to Enhance Students' Conceptual Understanding in Vector Components

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With and without physical context, we explored 59 undergraduate students' conceptual and procedural understanding of vector components using both open ended problems and multiple choice items designed based on research instruments used in physics education research. The results showed that a number of students produced errors and revealed alternative conceptions especially when asking to draw graphical form of vector components. It indicated that most of them did not develop a strong foundation of understanding in vector components and could not apply those concepts to such problems with physical context. Based on the findings, we designed a worksheet to enhance the students' conceptual understanding in vector components. The worksheet is composed of three parts which help students to construct their own understanding of definition, graphical form, and magnitude of vector components. To validate the worksheet, focus group discussions of 3 and 10 graduate students (science in-service teachers) had been conducted. The modified worksheet was then distributed to 41 grade 9 students in a science class. The students spent approximately 50 minutes to complete the worksheet. They sketched and measured vectors and its components and compared with the trigonometry ratio to condense the concepts of vector components. After completing the worksheet, their conceptual model had been verified. 85% of them constructed the correct model of vector components.

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