WHAT CAN WE LEARN FROM TOP 10 PERCENT STUDENTS IN BIOEMCHANICS?

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The aim of this study was to revisit the previous study and identify the behaviours that help undergraduate students who achieved a final grade above 90th percentile and achieved most normalized gain of biomechanical concepts. A total of 149 students were recruited from introductory biomechanics classes from three public universities. The first version of Biomechanics Concept Inventory was given during the first and last week of the sessions with a 19-item questionnaire. Fifteen high achievement students in final grade and normalized gain were selected for further analysis. Students' interest in biomechanics was identified as a common factor that related to high final grades and greatest normalized improvement. Students learning biomechanics in small groups and playing an active and important role may enhance learning and final grade.

KEY WORDS: BCI, high achievers, learning behaviours, biomechanics learning.

INTRODUCTION: Enhancing students' learning has been a focus of research in teaching and learning for many decades, especially several studies have identified biomechanics as a difficult subject for kinesiology and exercise science undergraduate students to master (e.g., Hsieh, Mache, & Knudson, 2014; Knudson et al., 2003). In order to understand how students learn, a vast body of research has examined a variety of factors such as teaching and learning behaviours, teaching methods, etc. (e.g., Champagne, Klopfer, & Anderson, 1980; Hsieh & Knudson, 2008; Hsieh, Smith, Bohne, & Knudson, 2012; Garceau, Ebben, & Knudson, 2012). In the previous studies, students' final grade is significantly associated with GPA, credits passed in physics, interest in biomechanics, perception of the biomechanics application, hours working at job, frequency of visiting instructor, and role played in the study group. On the other hand, students' normalized improvement was associated with GPA, interest in biomechanics, perception of application of biomechanics application, and role played in the study group (Hsieh et al., 2012).
Although studies have identified several crucial factors that related to students learning, the findings from these studies were based on examining the performance of entire groups of students which may omit some important information on outliers due to the limitations of parametric statistics or the design of the study. Moreover, the findings tend to benefit students who are below average achievers and to improve their performance toward the average. Thus, students who improved the most from the pre-test and students who had the highest final grade can be an interesting group for further analysis. Additionally, identifying other hidden factors, characteristics, or learning behaviours specifically from "good" students may help inform instructors as well as students. Therefore, the purpose of the current study was to re-examine the association of top 10% students' learning behaviours and normalized gain and final grade separately from the previous study (Hsieh et al., 2012). The hypothesis is that different characteristics of learning behaviours can be identified from this homogeneous high achiever group and provide more direct instruction or recommendations on successful learning behaviours for undergraduate biomechanics curriculum.

METHODS: Over 150 students who were enrolled in introductory biomechanics classes were invited to participate from three public universities located in central and western United States. All policies and procedures of using human subjects were followed and approved by the university institutional review board. A total of 149 students completed the study protocol and data from 7 students were disregarded due to incompletion of the survey questions (n = 5) and non-compliance (n = 2) standard of a decrease in performance of more than 4 questions on the post-test. This non-compliance rate of 1.67% was lower than previous studies using similar test (Henderson, 2002; Hsieh et al., 2012; Hsieh & Knudson, 2008; Knudson et al., 2003).

The first version of Biomechanics Concept Inventory (BCI; Knudson, 2003) was provided to participants during the first and last weeks of the academic term, respectively. A 19 items questionnaire (Table 1 and 2) was provided during the post-test session. Students' final grade assigned by the instructors in percentage and normalized gain of the BCI were obtained. A normalizing gain (G) variable (g = (post-test score – pre-test score) / (maximum possible score – pre-test score)) was used to indicate students' normalized learning (Hake, 1998). The top 10% of the students with highest final grade and normalized gain were selected for further analysis (n = 15). Non-parametric statistics (Spearman's Rho correlation) were performed to examine the association between students' learning behaviors and the normalized gain and final grade separately. Additionally, the discussion also included the frequency of the responses in the applicable items such as gender.

Table 1
Characteristics of Students Learning in Biomechanical Concepts for Top Normmalized Gain

Gender	9 F; 6 M	Perceptions of Biomechanics application	8 ± 1.51
Cumulative Grade Point Average	3.33 ± 0.44	Total credits taking currently	14.47 ± 2.80
Hours studied/week	3.43 ± 2.46	Hours of working at job/week	12.2 ± 12.1
Hours working on lab/week	1.57 ± 0.47	Frequency of visiting instructor	1.87 ± 1.20
Percentage of assigned reading	63 ± 36.24	Length of visiting in minutes	10.47 ± 11.29
Credits passed in Math	5.73 ± 3.06	Study biomechanics in groups	13 Yes; 2 No
Credits passed in Physics	3.33 ± 3.66	Frequency of group study meeting	3.5 ± 3.52
Satisfaction of instructor	8.93 ± 1.10	Length of meeting/session in minutes	53.57 ± 30.97
Interest in Biomechanics	8.2 ± 1.26	Role played in study group	12 L; 1 F
Normalized Gain	0.52 ± 0.08	Final grade in percentage	90.25 ± 8.14

Note: Values in each category represent mean and SD for both table 1 and 2 (n = 15). For Role played in study group, L represents leader and F represents follower.

Table 2
Characteristics of Students Learning in Biomechanical Concepts for Top Final Grade

Gender	7 F; 8 M	Perceptions of Biomechanics application	8.67 ± 1.18
Cumulative Grade Point Average	3.69 ± 0.28	Total credits taking currently	15.53 ± 1.77
Hours studied/week	2.24 ± 1.87	Hours of working at job/week	9.03 ± 9.65
Hours working on lab/week	0.92 ± 0.48	Frequency of visiting instructor	1.47 ± 2.07
Percentage of assigned reading	63.47 ± 46.38	Length of visiting in minutes	10 ± 15.92
Credits passed in Math	5.53 ± 4.09	Study biomechanics in groups	10 Yes; 5 No
Credits passed in Physics	4.6 ± 3.68	Frequency of group study meeting	1.6 ± 2.02
Satisfaction of instructor	8.43 ± 1.59	Length of meeting/session in minutes	47 ± 44.87
Interest in Biomechanics	7.8 ± 1.37	Role played in study group	7 L; 3 F
Normalized Gain	0.37 ± 0.13	Final grade in percentage	97.42 ± 2.71

RESULTS: Only four out of fifteen students appeared in both top final grade and normalized gain groups. In high achieved normalized gain group, the variables had significant association with the improvement were student interest (r_s = .60, p < .01) and length of visiting instructor (r_s = .48, p < .05). Interestingly, GPA (r_s = .14, p = .31) and perception of application (r_s = .21, p = .22) had no significant relationship with normalized gain. In this group, 13 out of 15 students (87 %) reported participating in study groups and 12 out 13 students reported as the leader for the group (92%). It was worth noting that 7 out of 15 students (47%) reported did not take any college level physics class (Table 1).
In the high final grade group, the variables had significant association with final grade were GPA (r_s = .61, p < .01), physics credits taken (r_s = .50, p < .05), and student interest (r_s = .60, p < .01). Perception of application had no significant relationship with final grade (r_s = .29, p = .15). Ten out of 15 students (67%) reported studying biomechanics in groups and 7 out of 10 students (70%) indicated that they were leader of the group. Interestingly, there were 5 students (33%) reported that they have not taken any college physics credits (Table 2).

DISCUSSION: As expected, students' interest in biomechanics played an important indicator for improvement and even final grade. This is supported by Schiefele (1991) who summarized that the benefit of interest to learning according to empirical studies are: 1) quality of learning results, 2) use of learning strategies, and 3) quality of learning expereience. Therefore, promoting students interst in biomechanics during learning is essential. The best strategy is to engage students learing by connecting the concept to their background and experience with active learning techniques such as problem-based learning (Duncan & Lyons, 2008). Moreover, while overall data set showed that students' perception of applying biomechanics toward their future career was an important indicator for both normalized gain and final grade, it had no association with normalized gain and final grade for high achieved students. This finding may just due to the limitations of the statistical methods because the rating from students were still high (about 8 out of 10).
One other interesting finding was that students with high improvement had significant relationship with the length of visiting their instructor. This represents faculty-student contact in and out of classes as a crucial factor to promote students' learning. This contact can enhance students' motivation and involvement in learning (Chickering, & Gamson, 1987). One strategy can be initiated from the instructor that is to setup mandatory meetings with individual or small group of students. For large classes, instructors may meet with small group of students to lower the faculty student ratio and promote faculty-student contact. This small group meeting can also facilitate the setting of group study which was found as an important key to learning (Hsieh et al., 2012). The findings from this study not only showed the importance of group study but also point out the role taken on by a student during group work (about 50% of students in both groups identified themselves as leader). This is also supported by the active learning strategies such as cooperative and collaborative learning (Dougherty, Bower, Berger, Rees, Mellon, & Pulliam, 1995; Lumpe, & Staver, 1995). One other strategy to adapt this active learning into the classroom setting is to assign students into small groups to practice problem-based learning and have each student rotate being the leader for different problems.
Last, there were only four high achieved students appeared in both final grade and normalized improvement groups. This indicated that students who improved the most didn't mean that they would have high final grade or vice versa. This points out the limitation of interpreting normalized gain since normalized gain may be skewed due to the pre-test (Brogt, Sabers, Prather, Deming, Hufnagel, & Slater, 2007). Moreover, almost half of the students did not take physics in high improvement group. This represents that even without physics as a pre-requisite, students can still gain knowledge of biomechanics. However, taking physics may benefit their final grade since two third of students took physics in high achievement final grade group. This was also supported by the overall data set that physics credits was significantly associated with final grade (Hsieh et al., 2012). Finally, students with highest normalized gain spent about five hours weekly on studying and working on lab materials while students with highest final grade spent about 3 hours. Although high improvement

group did not necessarily have the highest final grade, their mean final grade was still within the 90th percentile (see Table 1). This indicates that BCI is a reliable tool to measure students' performance even for high achievers.

The limitations of the current study are: 1) small sample size and homogeneous for both groups, 2) compound learning behaviours were not examined, and 3) intrinsic and extrinsic learning factors were not evaluated. Further studies are required to examine the performance and other characteristics for high achievers in biomechanics.

CONCLUSIONS: The current study confirms that interests in subject matter is important for learning biomechanical concepts even for high achieved students. Other than student interest, promoting faculty-student contact can enhance the learning of biomechanical concept. For high achievers in both groups, students all benefited from studying in small groups and most importantly, being active in the study group was a strong indicator. College level physics may not be important for gaining biomechanical concepts but it is crucial for achieving high final grade. BCI was confirmed to be reliable to evaluate high achievers' performance.

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