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Approaches to Teaching Biomechanics

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PART I: RECOGNIZING AND REVEALING "HIDDEN TRANSFORMATIONS[1]" IN BIOMECHANICS

Transformation Type[1]	Illustration from Arons' Introductory Physics (1997) [2]	Illustration from Grossman's Introductory Psychology (2005)	Illustration in Biomechanics Class
PROCEDURAL: Transforming knowledge so that an abstract concept can be converted into a procedure which can be used in a concrete situation.	Teaching students to go from the rote or declarative memory of "area equals length times width" to actually measuring a rectangle and computing the area.	Teaching students to go from the rote memory of the definition "reactive formation" to identifying an example.	Teaching the students to go from the rote or declarative memory of "velocity equals distance divided by time" to actually determining velocity
CONCEPTUAL : Abstracting more general principles from declarative (rote) or procedural knowledge.	Teaching students to change the level of abstraction of their definition of area to something like "selecting a unit square, imposing a grid on a figure, and counting the squares within it."	Teaching students to go from definitions of a specific defense mechanism to an understanding of how all of them are derived forms of "repression."	Having the students explain why small variances in motion capture marker location can result in large marker velocities even when the subject is not moving and, thus, how errors can arise in measurements (even with apparently precise systems).
CONTEXTUAL: Transforming knowledge so that a concept or procedure can be used on a problem embedded in a new situation.	Asking students to find the area under a graphed curve after learning to deal with areas of irregular figures	Asking students to use "reaction formation" sequentially in combination with other defense mechanisms to modify a single instinctual impulse (in a more "real life" situation).	Asking students to explain the sources of torque involved in gripping an object after learning to explain the torques involved in maintaining stance.
ANALOGICAL: Locating the likeness between two concepts or operations.	Asking students to use their understanding of "area" to comprehend "volume."	After students understand Freud's idea of "defense mechanism" using their intuition to comprehend Roger's idea of "distorted symbolization" of experience.	Using the students' understanding of the impulse momentum relationship in a linear coordinate system to explain its relationship in an angular system.

SYMBOLIC: Using symbols to represent relations.	Translating English sentences into algebraic equations. For example, once students can compute densities when given volumes and masses then using densities and masses to solve for volumes	In psychology, symbols are used in diagrams for classical conditioning: Before: NS →No Response US→UCR During: NS→US→UCR After: CS→CR	Once the students understand a biomechanical concept and can explain it in words (verbally or written), have them use symbols to represent the same concepts.
METAPHORICAL: Using one kind of symbol system to stand for or represent a concept that was originally expressed in a different symbol system.	After understanding ratios in numbers and formulas, moving to "graphical representations." Newtonian mechanics require that students use a frictionless world as a metaphor to facilitate understanding of motion	Moving from a verbal chart of the operation of a defense mechanism to doing a flow diagram of the same processes.	Once students understand the algebraic relationship between impulse and momentum, have them predict changes in momentum based upon time-series plots of force.
ARBITRARY: Transformations that are often fixed by the history of a field and therefore have little obvious rational basis; they are often extremely hard for students because faculty take them for granted and do not even notice the student's problem.	Using the letter "v" to stand for instantaneous velocity and change in instantaneous velocity without informing students of the switch Using common word like "force" in an uncommon way in physics.	Freud uses the word "sex" to include a much wider range of pleasurable experiences than we refer to in everyday language. (Others such as "anxiety," "depression," "schizophrenia," and "multiple personality" have different, more precise definitions in psychology.	Using the letter "d" to stand for botch distance and moment arm. (Fix by explaining that "d" as used for distance is distinct from "d" used for moment arm.

[1]Table adapted from Grossman, R.W. (2005). Discovering hidden transformations: Making science and other courses more learnable. *College Teaching*, 53, 33-40.

[2]Grossman (2005) summarized Arons, A.B. (1997). *Teaching Introductory Physics*. New York: John Wiley and Sons.

PART II: EXAMPLE STUDY GUIDE

Prior to each class, the students are assigned a study guide. At the beginning of class, I give them a small quiz for which they may use their completed study guides. After a *short* lecture in class, the students break into groups and discuss their study guide answers. They are asked to make any changes in red ink so that I can evaluate their answers prior to class and their answers as a consequence of discussion. (I accept the red ink as the final answer.) I walk around the room to answer questions and facilitate discussion. I then generally select one or two of these questions to discuss as a whole class.

Balance Concepts

Name:_____ Date: _____

Read Chapman pages 56-65 to answer the following questions. Do not use red ink.

1. Level 1 - Explain the relationship between the center of mass (CM) and base of support (BOS) for the maintenance of upright stance.

2. Level 1 - Is it necessary to have static equilibrium in order to maintain upright stance? Why or why not?

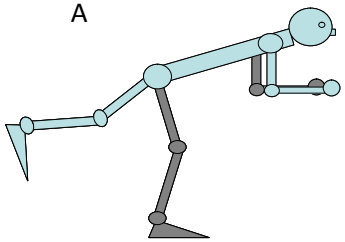
3. Level 1 - Looking at the graph on Fig 4.2, would you say that impulse is equal to zero over the entire golf swing? What might be the implications for balance?

4. Level 1- Why is energy spent during standing?

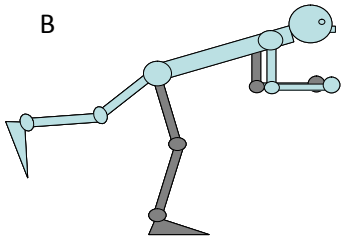
5. Level 2 - To keep from falling explain the advantage of orienting the BOS so that its greatest dimension is in the direction of an expected external force.

6. Level 3 - In figures A and B below, draw the forces and moment arms acting in the diagrams when the figure is balance and when the figure is falling forward. You will need to draw the CM, the force due to the weight of the CM, the force due to the COP (GRF), the CM moment arm creating a moment about the ankle, and the COP moment arm creating a moment about the ankle. Explain using the equation for moment why your drawing makes sense.

A



B



PART III: EXAMPLE REFLECTIVE ASSIGNMENT

Three reflective assignments are assigned over the course of the semester and they are intended to help the students to continue to develop a process for using mechanics to examine human motion. Assignments are collected and reviewed, and I give students feedback during short meetings in my office. If needed, I will cancel a class to fit these meetings into my schedule.

Reflective Assignment #1

Reflective assignments are intended to give you an opportunity to consider your understanding of the course material. It can also be helpful for contextualizing course content with your other physical education studies. Read each of the four statements below and write a reflective response. Each reflective response should be TYPED and approximately ½ page in length (single-spaced, 12 pt font). The reflective assignment will be collected at the beginning of class on:

Wednesday, Feb 17th

Statements:

1. What I understand really well is… (Please show your understanding and provide an example. Write it as a level 2 type problem.)
2. What I do not understand well is… (Please start with an example and show the parts that you do understand. Then show where the concept breaks down for you. Write it as a level 2 type problem)
3. What surprised me was…(in terms of course content)
4. A class concept fits in my other courses in the following way…

Notice that students are sometimes asked to complete questions as "level 1, level 2, and level 3" type problems. At the beginning of the semester, the students are provided with a rubric (attached next page) that specifies what a successful level-type problem entails. By asking them to write specifically to a set of criteria, I can better determine the extent to which they have mastered class content and the transformations associated with it.

PART IV: CLASS RUBRIC

	Level	No Credit (0%)	Partial Credit (75%)	Full Credit (100%)	Transformation(s) Addressed
Competency					
Thoroughness	1	No or only a slight attempt is made.	Question is answered, but not completely	Question is completely answered	Procedural/Conceptual/Contextual
Approach	1	Application of course content does not apply to question	Application of course content is adequate, but another choice would have worked better	Application of course content is appropriate to answer the question	Procedural/Conceptual/Contextual
Composition					
Vocabulary	1	3 or more misused words; use of text messaging shortcuts	1 misused word	All words are used appropriately	Procedural/Conceptual/Contextual /Arbitrary
Grammar	1	Incomplete sentences		All sentences are complete with a subject and a verb.	Procedural/Conceptual/Contextual
Formulas					
Mechanical formula	2	Mechanical formula(s) not provided	Mechanical formula(s) provided, but a better choice could have been made	Appropriate mechanical formula(s) provided	Procedural/Conceptual/Contextual
Variable definitions	2	No formula variables correctly defined and identified	Most formula variables correctly defined and identified	All formula variables correctly defined and identified	Procedural/Conceptual/Contextual /Arbitrary
Mathematic Relationships	2	Effects of change of one variable on the other variable(s) not explained correctly	Effects of change of one variable on the other variable(s) partially explained correctly	Effects of change of one variable on the other variable(s) explained correctly	Procedural/Conceptual/Contextual /Symbolic/Arbitrary
Diagrams					
Object of interest	**3**	Object of interest not drawn or drawn very small; object is not identified		Object of interest drawn clearly and identified	Procedural/Conceptual/Contextual
Forces and moments	3	A few forces and moments are drawn and labeled; force and moment direction is incorrect; no sense of force or moment magnitude is provided	Most forces and moments are drawn and labeled; force and moment direction is correct; no sense of force or moment magnitude is provided	All forces and moments are drawn and labeled; force and moment direction is correct; sense of force or moment magnitude is provided	Procedural/Conceptual/Contextual /Metaphorical
Moment arm (if needed)	3	No moment arms drawn	Most moment arms drawn, but are not labeled. Moment arms do not intersect lines of action at right angles	All moment arms are drawn and labeled. Moment arms intersect lines of action at right angles	Procedural/Conceptual/Contextual /Metaphorical
Cleanliness of diagram	3	Diagrams are full of scribbles and erroneous marks		Diagrams are free from scribbles and all erroneous marks	Procedural/Conceptual/Contextual