DESCRIPTION OF TEACHING MATERIALS:

The goal was to enable students to understand the advantages of gear ratios and different gears on bicycles. From this, they would work through inertia and torque to rotational energy. This would then relate back (via angular velocity and acceleration) to the bicycle going up and down hills and why different gears were beneficial for these situations.

The first two activities are included and a partial Activity 3. The third is partial as to show where the Thinking Ahead part of Activity 2 was headed. These materials are pretty self-explanatory in regards to what the students will do. The (Consider) bullets are set apart because they are the items that will be graded as completion only. They are there to make the student think and commit to a theory before moving on.

The materials are aimed at a General Physics audience in a similar style to the Engineering Physics Studios with the students working in groups. The text is Physics, Principles with Applications, Fifth Edition by Giancoli Chapter 8. Note that some of the available homework problems are quite similar to the parts of the activities.

The estimated time for each activity is about 2-3 hours for these students. This was difficult to determine so there may be quite a variation in practice.

ANALYSIS OF INSTRUCTIONAL DESIGN

Each activity will be inspected and analyzed individually. Then the set will be discussed as a whole.

ACTIVITY 1
RADIANS AND ANGULAR VELOCITY
(Reference Attachment 1)

This starts on a rather concrete basis on a topic that most students probably believe they already understand. Upon playing around with the bike wheel and its convenient spokes (careful not to use spokes that overlap) the student will be familiar with radians as opposed to degrees. This is Knowledge and Comprehension in Bloom’s taxonomy of the cognitive domain. However, the determining the ratio that $\pi$ represents is a bit more formal in reasoning and also nearly Analysis by Bloom’s taxonomy. By using this information (radians and $\pi$) in calculating angular velocity repeatedly for slightly different scenarios, a behavioral type of learning is employed. This enables the student to gain confidence in their knowledge and also focus more on the ideas than the calculation. The activity gets much more formal in its reasoning and higher in Bloom’s
taxonomy level when dealing with angular velocity. It again starts concretely, but moves into a more formal vocabulary, has the student apply her/his knowledge to different situations and determine a mathematical relationship (Analysis).

Developmentally, this activity starts with what the student is already familiar. Bicycle wheels, clickers, faster clicking implying faster speeds are common to most childhood experiences. These activities take the familiar and use them to build upon and translate newer concepts such as radians and angular velocity into what is more familiar to the student. This will help them in connecting this new information to their existing mental model. Gears are also familiar to a student from their bicycle experience, but they most likely have not thought about them in terms of angular velocity. This new approach may present a conflict to their existing model. These conflicts and others are prompted by the (Consider) questions. These force the student to think about and commit to a theory before moving on. The act of verbalizing a thought can at times be enough to make them think about it differently.

**Activity 2**
**Tension and Angular Acceleration**
(Reference Attachment 2)

This activity starts with a (Consider) question. This could be formal reasoning, but depends on the student’s level of understanding. Then it gets more concrete in its working. The student does an experiment which is exactly what was asked about in the (Consider) question. These are at the Knowledge, Comprehension, and Application level in Bloom’s taxonomy. When the activity has the student include a previously covered topic, Newton’s Laws, this pushes into Analysis and more formal reasoning. Then by using the angular acceleration as an anchor problem, the activity moves again into transitional reasoning levels. However, this is mostly due to the vocabulary level in this activity as compared to activity 1 that is much more abstract and therefore more formal in its reasoning level.

Developmentally, this activity starts right out with a possible misconception. (I feel it is because I find myself having it, and I should know better by now!) It follows with a learning cycle. Depending upon the student’s understanding, the answer to the first question is usually that the mass will fall with the acceleration due to gravity – a misconception. In then performing the experiment, the cognitive conflict is created. Then a simpler activity reveals that mass couldn’t move at the same acceleration as gravity – a resolution. This then sets up well for the next concept and some exploration for it is done.

**Activity 3**
**Torque and Inertia**
(Reference Attachment 2)
Its title shows its more formal in reasoning. These are new terms and not known. It’s staying at the Comprehension or Application level of Bloom’s Taxonomy. It pushes toward total formal reasoning with its mathematical representations and manipulations. There is some concrete reference by actual data collection, but all the new knowledge is from calculation and manipulation. It is behavioral in learning type because it is quite repetitive in that the student does these calculations for several masses.

There isn’t really a developmental setting for this. But be reminded that it is only the first half of the activity for showing what would follow the Thinking Ahead section of Activity 2.

**SUMMARY**

All of these activities aid the student in acquiring Knowledge, Comprehension, Application and some Analysis information as classified by Bloom’s taxonomy. They each have a connection to real-world situations, which is beneficial for concrete reasoning. Activities 1 and 2 then build on that re-world situation in the way that Roschelle and Redish recommend. Activity 3 moves much faster. This pushes the reasoning to a transitional or formal (in the case of Activity 3) level of reasoning by having the student think about and do experiments and calculations related to these real-world situations.

Not mentioned previously, the students are working in groups. This enables them to discuss any and all of the experiments and questions including the (Consider) questions. Discussing issues with peers has proven to be beneficial as discussed by Mazur. Some of the questions in the activities are quite similar to his reading quizzes or ConcepTests.

Each activity builds upon the previous one attempting to refer back to anchor problem and situations as suggested by Redish. These activities are designed in a constructive and personal way but attained in a more social environment. Each student is working it out for him/herself with the help of peers. Activity 3 uses more transmission-style learning. One can hope that it would not remain so for the rest of the activity.

This mixture of concrete and formal, experiment and calculation, thinking and doing, targets several dimensions of learning style as presented by Felder. A number of his suggested teaching methods are included to some extent in all of the activities. For example, his suggestion to provide time in class to think about the material being presented (reflective) and for active student participation is addressed by the (Consider) questions and some others as long as the format of the class doesn’t push its schedule too much (quite difficult to achieve at times).

This mixture also follows some of the suggestions by Norby to improve teaching to female students. By addressing both of these issues, perhaps the concerns of science majors and those who left science as reported by Seymour have been alleviated. More of
the capable non-science majors, defined by Tobias as the second tier, will enjoy and learn more physics. This leads to a better educational experience for everyone in the class.
REFERENCES:


Tobias, S. (?), *They’re Not Dumb, They’re Different*. 