

Objectives

- Aid an engineer’s ability to discover and understand biological phenomena
- Eliminate the need for engineers to “biologize” a problem
- Provide a bridge between engineering terminology and biological terminology
- Develop and verify a classification scheme for the type of problems an engineer is tasked with
- Encourage the development of problem driven biological inspirations rather than solution driven

Approach

- (1) Classification of current products
 - Many products have already been biologically inspired
 - Each one of these products is applicable to a higher level engineering classification
 - Have experts classify these products into their respective classifications, some products may fall into multiple classifications
- (2) Classify the associated biological phenomena
 - Put each inspiring biological phenomena into the same classification that its inspired product is classified into
- (3) Discover similar phenomena
 - Using the inspirations that are already known, similar biological phenomena can be discovered
 - Classify new phenomena into the same classifications as the similar phenomena
- (4) Populate database
- (5) Enable searching

Experimental Procedures

- (1) Data Collection
 - Found 50 products already inspired by nature
- (2) Initial classifications developed by Murray and Mocko
 - Materials, Machines, Structures, Energy, Fluid Dynamics
 - Products were categorized by Murray into these classifications
- (3) Closed Card Sorting
 - CEDAR members classified the inspirational biological phenomena
 - High level of variation in the results
 - High amount of false negative responses - Indicates not being able to identify an inspiration that has already occurred
- (4) Open Card Sorting
 - Performed by two students (one graduate and one undergraduate)
 - Asked to develop their own set of classifications
 - P1 – Materials, Chemical, Mechanical, Structure, Electrical, Heat Transfer, Fluids
 - P2 – Materials, Machines, Mechanics of Materials, Energy, Fluids/Aero, Heat Transfer

Open Card Sorting Results

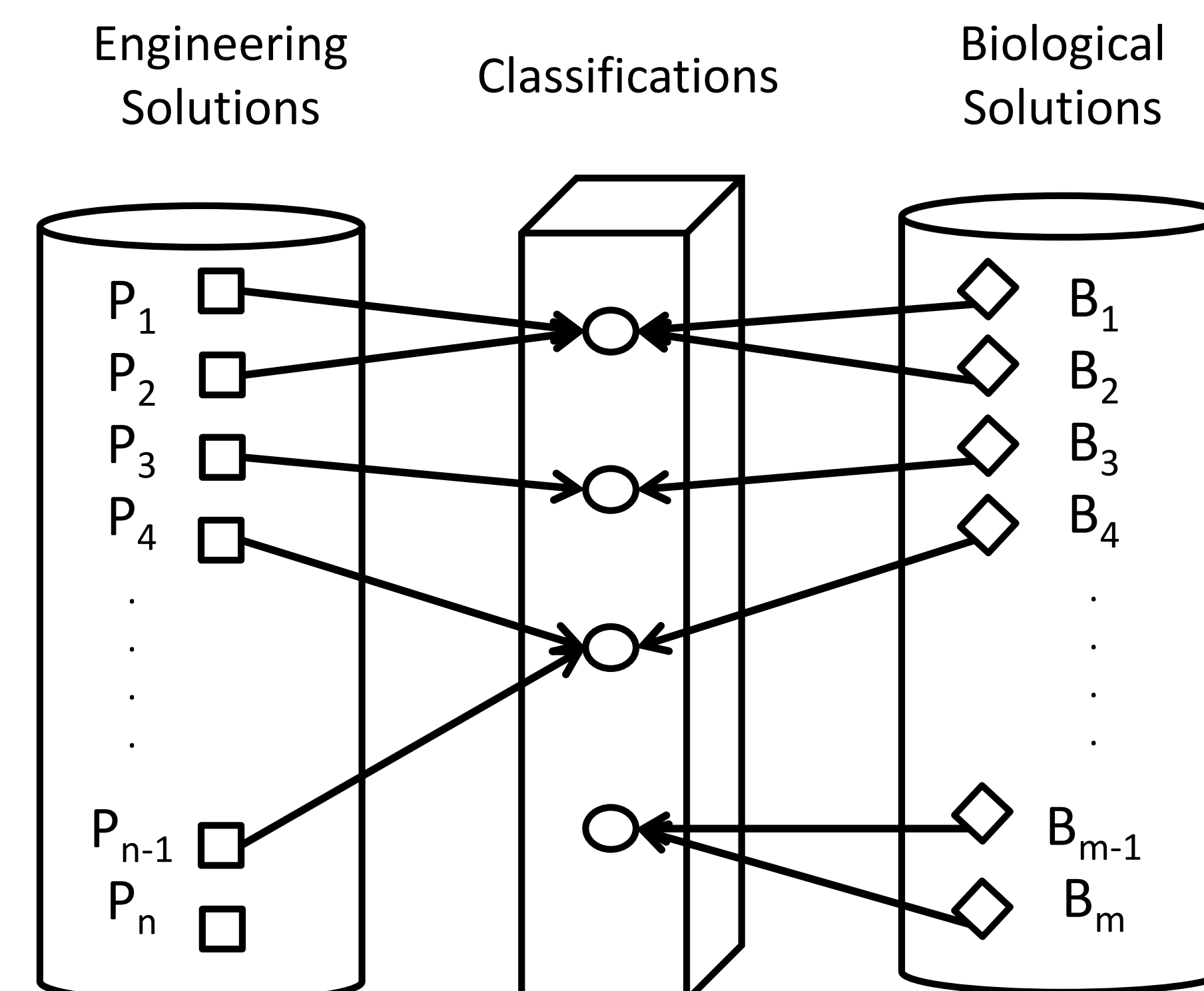
- Participants develop similar classification schema
- Participants collaborated and created a “super-set” of classifications
- Reclassified with new set of classifications
- Cohen’s Kappa value computed between each participant before and after collaboration (>0.6 desired)

Raters	Round 1 Cohen’s Kappa	Round 2 Cohen’s Kappa
Original – P1	0.38	0.91
Original – P2	0.53	0.75
P1 – P2	0.47	0.67

Classifications

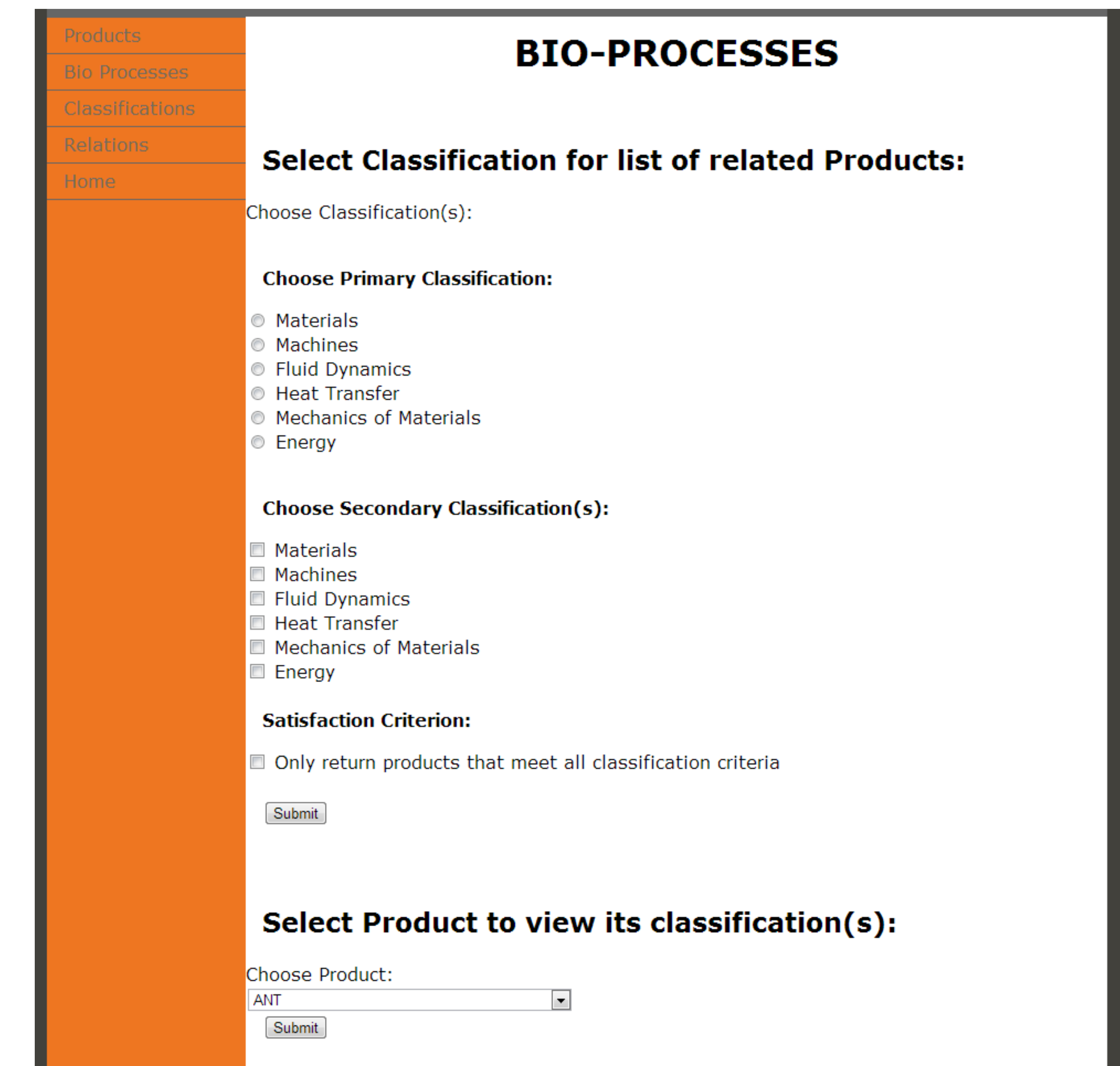
Classification	Definition	Example Variables of Interest
Materials	The development of a material’s structure, at the atomic or molecular scales in order to improve its macroscopic properties	Coefficient of Friction, Hardness, Density, Ductility
Machines	Device used to alter, direct, and transmit forces for a useful purpose (Myszka)	Position, Velocity, Acceleration, Work
Fluids/Dynamics	Concerned with the effects of external forces acting on a body or system of bodies	Drag, Lift, Pressure
Heat Transfer	Dealing with problems relating to heating and cooling	ΔT , q , q' , q''
Mechanics of Materials	The ability of a structure to withstand applied stress and strain without failure	Stress, Strain
Energy	Concerned with the ability to capture and transfer power from another source	BTU, Voltage, Watts,

Classification Process



Bio-Database to Ease Retrieval

- A database is under development to aid the discovery of inspirational biological processes
- Data structure based on the classification process described previously
- Database developed using a MySQL server on the back end, and the web interface front end was developed using PHP
- Database structure was developed to allow users to insert products and processes into the database
- Users can then relate the inspirational processes to the inspired products, and tag the classification that the products and processes fall into. Users can also relate biological processes to similar processes
- The database can be searched by classification, product, or process. A screen shot of the search page can be seen below:



Future Work

- Perform TF-IDF tagging to the collection of documents
 - Explore possibility of sub-classifications, or groupings
- Determine means of classifying or relating biological processes
- Have undergrads perform classification experiment using the newly defined classifications
- Have biological students perform classification experiment
 - Can biologists identify the correct classifications?
- Finalize database, and evaluate usefulness as compared to other inspirational tools