The role of rheology in everyday fluid flow

From a mathematical modelling viewpoint, the simplest fluids have either negligible viscosity (inviscid flow) or a constant viscosity that dominates over inertial effects (Stokes flow). However, many fluids in our homes display interesting or challenging behaviour due to their non-Newtonian rheology. The viscosity of honey changes when it is heated, ketchup does not flow from the bottle unless it is shaken or tapped, and certain fluids such as cornstarch in water and shampoo are known as "shear thickening" and "shear thinning".

Mathematical models for non-Newtonian fluids must take into account their rheology. Modelling challenges could include:

- What is the optimal strategy for getting ketchup out of the bottle and onto your burger? Is a glass or plastic bottle better? How do you control the amount of ketchup delivered? What about shampoo?

- A spoon or finger can move through a cornflour–water mixture slowly with little impediment, but move too quickly and the mixture hardens, so that the spoon becomes stuck. Similarly, popular science shows sometimes include a presenter or audience participant running across the surface of a cornflour–water pool, but if the runner stops they will sink. What is the mechanism that allows for these two apparently disparate behaviours? Can a mathematical model determine the criteria for which a runner will sink into the pool or bounce of the surface?