Mathematical modelling in social sciences

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This presentation outlines the mathematising of population pyramids in secondary education. The population pyramids are presented as reduced schemas, making them more accessible for use in both mathematics and social science classrooms. The outcome is that such schemas show useful for describing relations between the shape of a population pyramid and aspects of macro-economic status of country; both when comparing countries with different shapes of the population pyramids at the same time period and when comparing one country over historical periods with different shapes of its population pyramids. Hence, this model opens for several societal applications, which in turn form bases for students' discussion and interpretations of both simulation models and the principle of mathematical reductionism.

Introduction

In mathematical modelling, Bergman Ärlebäck et al. (2015) suggests teaching mathematical modelling in symbiosis (interdisciplinary) with the subject of the application for the model. The standard is mathematics in symbiosis with science, technology and financial economics, where examples of the latter are percentage and interest rate (Frejd & Bergsten, 2018). The model is often stated in advance and it is usually a matter of calculating an answer in the form of a unique value - descriptive models. However, Niss (2015) points out that such teaching often fails to address the idea of reductionism (simplification), which is central to the modelling process itself.

In contrast to descriptive models are prescriptive models, which can be difficult to confirm empirically, though often used as a basis for decisions in politics, with an example in Petersson (2020). According to Niss (2015), prescriptive mathematical models are under-explored in subject didactics. Internationally, there are just a few search results in the school's social science subjects. These can be about only qualitatively examining a concept, for example curves for supply and demand, where Jägerskog (2020) states that modelling can provide different learning opportunities, depending on the combination of text, mathematical language and different illustrations. Prescriptive models work well to create an engaging and critical discussion about the models' relevance and usefulness (Frejd & Bergsten, 2018), which is an important argument for this study choosing the symbiosis of social science and mathematics.

Mathematising population pyramids

For the sake of highlighting, three exaggerated schemas are those in figure 1. A quantitative simulation model for these schema is the dependency ratio as the quotient of the non-working cohorts (8 green and red boxes for country 1) divided by the working cohort (4 yellow boxes for country 1) hence $8/4 = 2$. The dependency ratio is 1 for country 2 and it is 1.5 for country 3.

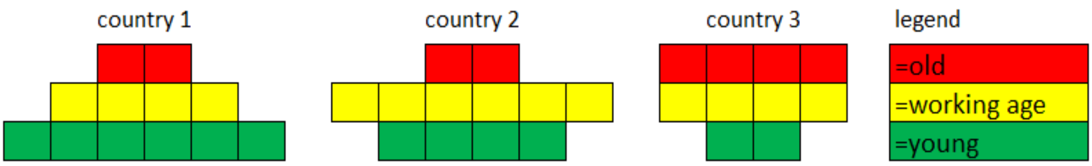

Figure 1. Simplified schemas of population pyramids

This quantisation of the shape of the pyramids allows discussing demographic causes for countries' different economies. For example, country 1, being similar to many European countries about 100 years ago, has a high dependency ratio, which causes less resources per person – poverty. In contrast, country 2 displays a large proportion in working age, and if their work is exported abroad it allows for a booming economy. This combination of demographic composition and economic status is actually seen today in so called tiger economies and was the situation in several previously booming industrial countries some decades ago though their population pyramids now have proceeded to a shape similar to that of country 3 with consequently slower growth of their economies.

One argument for teaching prescriptive modelling in school mathematics is that it equips the students with tools for not only reading isolated facts from diagrams and tables, but also allows them to think critically about reasons and causes for actual and possible events. One example is the topic of raising the pension age in country 3. Another argument is that of reductionism. Looking only at the shape of a population pyramid as a cause for economic status ignores the advancing of education, farming, medicine, science, technology and trade as other crucial aspects of a country's economy.

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