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Editorial: Probability and its paradoxes for critical thinking

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Editorial on the Research Topic
Probability and its paradoxes for critical thinking

Critical thinking can be conceptualized as the process of striving for successful solutions to problems presented in their natural context (Bailin et al., 1999; Davies, 2015). Many higher education institutions around the world have included critical thinking among their objectives (Bali, 2015; Zahavi and Friedman, 2019; Cruz et al., 2021). Generally, the tasks that can be used to develop critical thinking skills include defining arguments, evaluating reliability of sources, identifying fallacies and assumptions, using inductive and deductive logic, synthesizing information and making inferences. In this Research Topic, we show that solving probability paradoxes and puzzles can be used for enhancing crictical thinking in science, technology, engineering and mathematics (STEM) fields. It may involve many tasks that can be used for developing critical thinking in one's mind. This Research Topic draws on a variety of perspectives and case studies from higher education institutions around the world.

In their paper "*Meta-Critical thinking, paradox, and probabilities*", historian-*cum*-philosopher of science, Brittan and Taper argue that there is a great need to think critically about critical thinking, which they call "meta critical thinking" mainly due to a lack of clarity and agreement among researchers on what is required or involved in it. They take a close look at act of *distinction-making*, and *concept of evidence* in this regard. They show that when it comes to solving paradoxes the main aspect should be to think critically and creatively about inferences/conclusions through making distinctions and reflections. They provide three ways to unravel paradoxes; finding fallacies of premise, fallacies of argument, and making (new) distinctions (in comparison to old ones, if any). Since the third is the most fruitful way, as they argue, a sufficient account on "the discipline of distinction-making" is provided. They emphasize using two statistical inference paradigms of Bayesian and evidential statistics that provide significant perspectives to issues, such as what counts as "evidence," and how to quantify uncertainty in a given model. The authors provide their analyses for well-known probability/statistical paradoxes of lottery (Kyburg, 1961; Sober, 1993), old evidence (Glymour, 1980), and Humphrey's paradox (Humphreys, 1985, 2004) in their attempt show how critical thinking can be used in solving them.

In the published literature, most papers on paradoxes focus on a single paradox and then explain it, e.g., Bandyoapdhyay et al. (2011) and Wijayatunga (2014). In their paper, "*A toolbox to demystify probabilistic and statistical paradoxes*," two mathematicians,

Kelter et al., teamed with a philosopher, Susanne Spies to change this status quo regarding the paradox literature by providing a toolbox that can be seen as a guideline for the novice to isolate why a problem which a reader may encounter might appear paradoxical and, if so, how to resolve this. The toolbox contains analyzing tools such as causal reasoning, experimental design, Bayesian analysis and probabilistic modeling and is intended for handling paradoxes with a general framework under which many paradoxes could be brought in for their resolutions. Keeping this goal in mind, they revisit several well-known paradoxes, e.g., Simpson's paradox (Simpson, 1951), Bertrand's paradox (Shackel, 2007), and the two-envelope paradox (McGrew et al., 1997). They do this by identifying the class of scenarios where paradoxes arise and suggest ways on how to make choices in apparently contradictory situations. Though not exhaustive, the toolbox provides a roadmap for teachers to choose appropriate problems and help students to find the right method of addressing them.

In their paper titled "*Conceptualizations and instructional strategies on critical thinking in higher education: A systematic review of systematic reviews*," Andreucci-Annunziata et al. present results of a thorough systematic review, selecting quantitative and qualitative empirical studies on the promotion and development of critical thinking in higher education. They aim at answering two points. The first aim is to define what the common definition of critical thinking is. In fact, they conclude that there is no clear agreement among researchers and practitioners (Larsson, 2017), but find that the definition given in Delphi Project (Facione, 1990) is still valid. The second aim of the paper is to examine what the most common teaching strategies of critical thinking are. Again, they find that there is no clear agreement on the best ways, hinting that it can be contextual and discipline-dependent. Their conclusion is that, conceptually, critical thinking is related to both a disposition (a set of basic, predetermining affective propensities toward life in general and toward specific thinking situations) and some skills that are a higher order cognitive process. They emphasize that both dispositions and skills can be trained and enhanced. They have selected five reviews whose characteristics such as number of papers reviewed, type of the study, article selection method, etc. are given.

In their paper "*How do Chinese undergraduates understand critical thinking? A phenomenographic approach*" two educational scientists, Zhao and Liu show that there are limited studies done on critical thinking from the learner's perspective and, argue that better insights into how undergraduates understand critical thinking are important if we are to improve their critical thinking. Therefore, they undertake a study with Chinese undergraduates of different backgrounds with the overarching question of what the conceptions of critical thinking held by Chinese undergraduates are. To answer this, the authors employ a phenomenographic approach on student essays, an empirical research method aiming to study qualitatively different ways in which people perceive, understand, and experience various phenomena. They find that students conceptualize critical thinking as three types of skills and as a disposition that is the extent to which an individual is inclined or willing to perform a given thinking skill. Furthermore, they show that it can be a combination of these main two categories with varying proportions in given practical situation. The three skills in the first category are query and reflection of irrationality of things, objective and comprehensive understanding of things, and independent thinking with innovation while disposition is willingness and attitude.

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