World Academy of Science, Engineering and Technology
International Journal of Educational and Pedagogical Sciences
Vol:15, No:12, 2021

Don't Just Guess and Slip: Estimating Bayesian Knowledge Tracing Parameters When Observations Are Scant

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Abstract : Intelligent tutoring systems (ITS) are computer-based platforms which can incorporate artificial intelligence to provide step-by-step guidance as students practice problem-solving skills. ITS can replicate and even exceed some benefits of one-on-one tutoring, foster transactivity in collaborative environments, and lead to substantial learning gains when used to supplement the instruction of a teacher or when used as the sole method of instruction. A common facet of many ITS is their use of Bayesian Knowledge Tracing (BKT) to estimate parameters necessary for the implementation of the artificial intelligence component, and for the probability of mastery of a knowledge component relevant to the ITS. While various techniques exist to estimate these parameters and probability of mastery, none directly and reliably ask the user to self-assess these. In this study, 111 undergraduate students used an ITS in a college-level introductory statistics course for which detailed transaction-level observations were recorded, and users were also routinely asked direct questions that would lead to such a self-assessment. Comparisons were made between these self-assessed values and those obtained using commonly used estimation techniques. Our findings show that such self-assessments are particularly relevant at the early stages of ITS usage while transaction level data are scant. Once a user's transaction level data become available after sufficient ITS usage, these can replace the self-assessments in order to eliminate the identifiability problem in BKT. We discuss how these findings are relevant to the number of exercises necessary to lead to mastery of a knowledge component, the associated implications on learning curves, and its relevance to instruction time.

Keywords : Bayesian Knowledge Tracing, Intelligent Tutoring System, in vivo study, parameter estimation
Conference Title : ICMETL 2021 : International Conference on Mathematics Education, Teaching and Learning
Conference Location : Tokyo, Japan
Conference Dates : December 02-03, 2021