A MODEL FOR THE CLASSROOM ENVIRONMENT

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The Motivational Attitudes in Statistics and Data Science Education Research group is developing a family of validated instruments: two instruments assessing students' attitudes toward statistics or data science, two instruments assessing instructors' attitudes toward teaching statistics or data science, and two sets of inventories to measure the learning environment in which the students and instructor interact. The Environment Inventories measure the institutional structures, course characteristics, and enacted classroom behaviors of both the students and instructors, all of which interact with the student and instructor background. This paper will discuss our proposed theoretical framework for the learning environment and its development.

INTRODUCTION

The Motivational Attitudes toward Statistics and Data Science Education Research (MASDER) team received funding from the United States National Science Foundation to create a family of instruments: the Surveys of Motivational Attitudes toward Statistics or Data Science (SOMAS or SOMADS, respectively). The S-SOMAS and S-SOMADS instruments measure students' attitudes toward statistics and data science (S/DS), and the I-SOMAS and I-SOMADS measure the instructor's attitudes toward teaching S/DS. Considerable progress has been made on the S-SOMAS and S-SOMADS, and updates about all instruments and models are posted on the project website: https://sdsattitudes.com. By design, the development of the instructor instruments lags behind development of the student instruments. The I-SOMAS is currently in a pilot form, and the I-SOMADS is in early development. In addition to measuring student and instructor attitudes, the MASDER team is measuring the environment in which the instructor and students interact with the E-SOMAS and E-SOMADS inventories. We include in the environment (a) student and instructor backgrounds and attitudes, (b) institution and course features, (c) enacted classroom behaviors, and (d) the student-instructor relationship. This paper will provide an overview of the classroom environment's theoretical framework and a description of the progress that has been made towards the environment inventories.

ENVIRONMENT MODEL

The theoretical framework adopted for student and instructor instruments is Expectancy Value Theory (EVT; e.g., Eccles & Wigfield, 2002; Wigfield & Eccles, 2000), a commonly used theoretical framework for educational research. The choice of EVT for both student and instructor instruments will allow for closer parallels between student and instructor attitudes to be made. For more information on these theoretical frameworks, see Whitaker et al. (2018) and Batakci et al. (2018) for the student and instructor instruments, respectively. However, this framework is focused on explaining individuals' choices and is not suitable for accounting for features of the learning environment by design.

The MASDER team determined that the environment model should satisfy two criteria. First, the model should account for factors that affect instructional practices outside of the instructor such as the institutional setting in which they teach (e.g., Cobb et al., 2003). Second, the model should facilitate development of a sampling plan for creating nationally representative summaries of student and instructor attitudes. A review of the literature resulted in no established, appropriate theoretical framework that could be adopted without modification, but we found the "framework for the analysis of teaching practices and beliefs" (see Figure 1) developed by the Organisation for Economic Co-

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operation and Development (OECD, 2009, p. 91) for the Teaching and Learning International Survey (TALIS), which served as an inspiration for the Environment Model we developed. The TALIS provided insights about which components might be salient and the linkages among components.

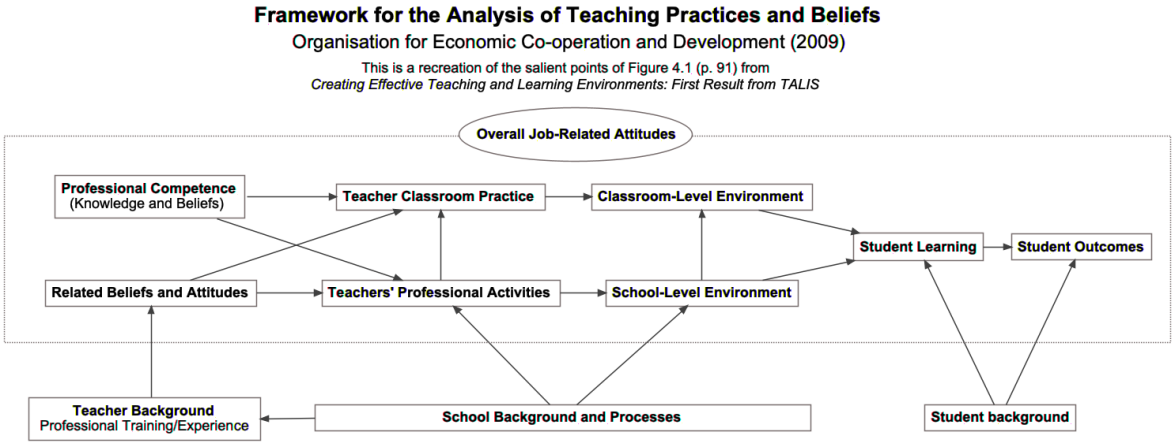

Figure 1. TALIS framework (OECD, 2009)

After reviewing the TALIS framework, participants in a Research On Statistics Attitudes (ROSA) workshop in 2017 rapidly developed and revised a model (using Post-it notes and group discussion) to meet the two aforementioned goals. The workshop participants were statistics educators and included both experienced instructors and researchers; informed by the TALIS model (OECD, 2009), this group drew on their knowledge and experience to develop and refine the model. The current E-SOMAS/E-SOMADS model (see Figure 2) represents a minor revision to the model developed at the ROSA workshop based on continued review of the literature and growth in understanding about the data collection aspects of the MASDER project. The *Organizational Features* component of the model supports both goals: it accounts for institutional characteristics, practices, and/or constraints that affect what instructors do, and it supports the development of a sampling plan by making explicit the hierarchical structure to be used. Although the unit of measurement is intended to be a statistics course, courses are nested within institutions, and characteristics of institutions can be used to ensure representativeness of a future sample. Salient *Course Characteristics* (e.g., modality, prerequisites) that might also be used in sampling are accounted for in the model. Recognizing that even identical courses can differ, the *Learning Environment (e.g., Classroom)* subcomponent was added.

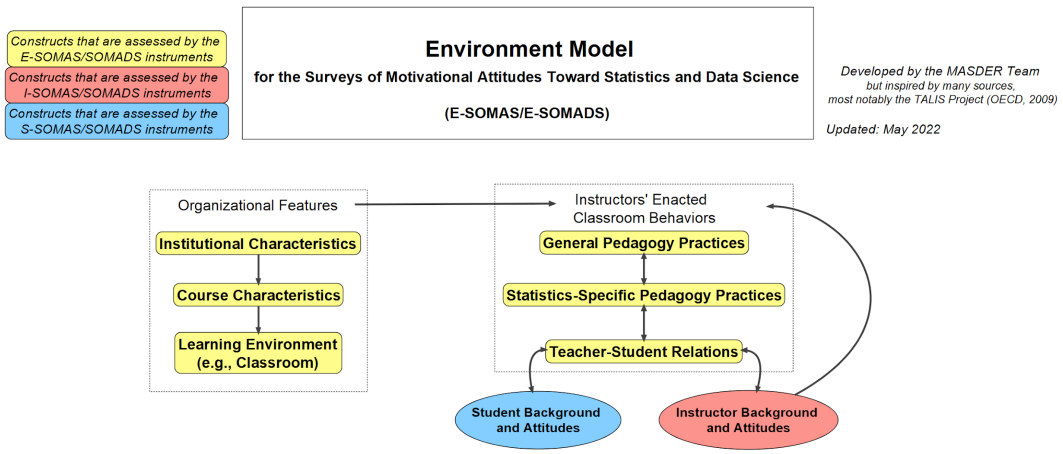

Figure 2. Environment model

The other component, *Instructors' Enacted Classroom Behaviors*, accounts for how the instructor facilitates learning. We reframed the TALIS components of *Teacher Classroom Practice* and *Classroom-Level Environment* as *General Pedagogy Practices* and *Statistics/Data Science Specific Pedagogy Practices* in our model; we distinguished between general and statistics/data science-specific practices because of this project's specific focus on attitudes in those courses. Because "teachers, students, and subject matter can only be understood in relation to one another" (Franke et al., 2007, p. 227), this component also accounts for Teacher-Student Relations. Students' and instructors' attitudes and backgrounds—accounted for by the EVT models and related to the TALIS background components—are incorporated in the model via the Teacher-Student Relations. The TALIS component of *Professional Competence (Knowledge and Beliefs)* was not explicitly accounted for because beliefs are accounted for in the EVT model, and measuring the knowledge of university-level statistics course instructors was not an aim of the MASDER project. Thus, the model shown in Figure 2 meets the two goals for the MASDER project while incorporating relevant TALIS model components (see Figure 1).

STUDENT AND INSTRUCTOR BACKGROUND AND ATTITUDES

The student and instructor backgrounds are measured through demographic or characteristics questions (CQs) and the attitudes constructs as defined by EVT. The CQs section of an instrument can get overly long, may not contain necessary information, and will be a section for institutional review board (IRB) scrutiny. Appropriate CQs must account for local norms and standards, and the target population. Race/ethnicity and gender are common types of CQs included on surveys administered in the US, and the format of these questions are connected to this context. The race/ethnicity CQs are based on the United States Census Bureau's (www.census.gov) approach to race/ethnicity which asks separate questions about race and whether one's origin is Hispanic or not. This format was chosen as the starting point for the CQs because the target population is students in the United States and the funding source for the project is the United States government. The gender question used by the project allows participants to provide responses beyond woman/man (e.g., nonbinary). We anticipate that researchers who wish to use surveys with populations outside the United States will adapt the CQs to account for local norms and standards.

We have CQs to measure respondents' race, ethnicity, gender, age in years, and language fluency; these CQs are the same for both students and instructors. For students, additional CQs are used to determine the student's rank in college (e.g., third-year student), major area of study, any minor area(s) of study, reason for taking the course, prior statistics experiences (e.g., secondary school courses), and first-generation university student status. For instructors, analogous questions are used to measure the instructor's professional rank, highest degree, field of study, prior teaching experience (with statistics courses and in general), department name, familiarity with the Guidelines for Assessment and Instruction in Statistics Education (GAISE College Report ASA Revision Committee, 2016), and engagement with journals and/or conferences that have a statistics education component. For student's major(s) and/or minor(s) and instructor's fields of study, we are using *The Classification of Instructional Programs* (CIP) codes from the National Center for Education Statistics (https://nces.ed/gov).

INSTITUTIONAL AND COURSE CHARACTERISTICS

To measure institutional characteristics, we are relying on the *Carnegie Classification of Institutions of Higher Education*, which lists each institution of higher education in the United States (Indiana University Center for Postsecondary Research, 2021). Examples of the almost 95 variables contained in this database include the type of institution, level of undergraduate degrees awarded (associate, bachelor, etc.), proportion of bachelor's degree majors in different fields of study, etc. Within an institution, the course characteristics tend to be stable because relevant variables are typically set for a longer period of time than a single semester or quarter. For statistics, we are measuring four course characteristics: mathematical prerequisite for the course, statistical prerequisite for the course, level of the course (introductory statistics, statistic I; intermediate statistics, statistics II; or other) and how the course is offered (face-to-face, online, synchronous, etc.).

LEARNING ENVIRONMENT AND ENACTED CLASSROOM BEHAVIORS

Enacted classroom behaviors have three parts, two of which are directly controlled by the instructor (pedagogy practices), whereas teacher–student relations are influenced by both students and instructor. We define pedagogy as the "tools" of the teaching profession. Just as carpenters expertly wield saws, hammers, chisels, etc., teachers employ their tools of pedagogy. If a specific teaching tool would be applicable for most instructors in higher education, then this tool would fall under general pedagogy practices. An example is the delivery method that might include lecture, flipped-classroom with mainly group work, discussion, hybrid-delivery (mixture of lecture and group work), etc.

Although some instructors may have a certain amount of control over their learning environment, in general, learning environment variables vary widely and remain out of the instructor's control. These features will need to be measured from term to term, and when an instructor teaches in a different classroom. Also, it is possible that different sections of the same instructor would differ, and learning environment variables would be the same if different instructors were teaching in the same classroom or with the same online platform such as the size of the classroom, ability to move furniture, on-line course platform, etc.

CONCLUSION

The environment inventories (E-SOMAS and E-SOMADS) are being developed by the MASDER team to measure the enacted classroom behaviors (pedagogy practices, statistics/data science-specific pedagogy practices, and teacher-student relations) in introductory statistics and data science courses. The CQs measure the backgrounds of the students and instructor and are developed according to local norms and standards in the United States, which should be adjusted accordingly with populations outside the United States. Lastly, we will judicially use institution and course characteristics and CQs. The first pilot of the E-SOMAS is being administered during Fall 2022.

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