The Experience Sampling Method: Investigating Students' Affective Experience

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Abstract. Improving non-cognitive outcomes such as attitudes, efficacy, and persistence in physics courses is an important goal of physics education. This investigation implemented an in-the-moment surveying technique called the Experience Sampling Method (ESM) [1] to measure students' affective experience in physics. Measurements included: self-efficacy, cognitive efficiency, activation, intrinsic motivation, and affect. Data are presented that show contrasts in students' experiences (*e.g.,* in physics *vs.* non-physics courses).

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INTRODUCTION

Research indicates that affective variables such as motivation, attitudes, and self-efficacy in physics are important contributors to learning outcomes in physics courses [2, 3]. Effective measurement of students' affective experiences is therefore desirable for improving physics instruction. In this paper, we will describe how a technique called the Experience Sampling Method (ESM) [1] can be used to collect in-the-moment evidence of individuals' or groups' affective and cognitive experience in different components of a physics course such as lecture, group work, and homework. We will discuss how the method works, the kinds of evidence it generates, and the validity and versatility of this evidence.

Our presentation of the ESM will be in the context of a preliminary study in which we employed the method to compare students' affective experiences in physics and non-physics courses. In this study, the ESM was used to collect data on the experiences of twelve students and three Learning Assistants (LAs) in an introductory calculus-based physics course. These data were complemented by concept inventories and affect surveys. Data are presented that compare the average affective experiences of the twelve undergraduate students in physics and non-physics courses to illustrate the ESM. Data from one LA are presented to further illustrate the methodology.

EXPERIENCE SAMPLING METHOD

The Experience Sampling Method was developed during the late 1970's to investigate experience in work, school, and leisure activities. One notable ESM study used for education research is the Sloan Study of Youth. In this study, researchers investigated the relationships between student experience, attitudes, and educational outcomes [4, 5].

In our preliminary study, ESM participants wore a pre-programmed watch that semi-randomly signaled them to complete an Experience Sampling Form (ESF). The participants carried the forms in a small booklet and were signaled 5-8 times each day. Collecting data across the whole day allows for the comparing of affective variables for an experience in a particular setting, such as physics, to the same variables in the rest of participants' lives. Taking self-efficacy as an example, the method allows for comparing self-efficacy in physics to self-efficacy for many other activities in students' daily routines, such as fixing breakfast, working out, or participating in a non-physics course.

The ESM provides ecological validity because data collection occurs within the day-to-day experiences of participants and close to the actual experience. The ESM can be compared to diary methods in which participants complete a daily survey about their experiences. Diary methods can introduce memory biases created by the separation in time between the event and reporting. The in-the-moment data collection of the ESM is designed to surmount this difficulty, and studies have shown differences in results between ESM and diary data collection [1,6]. In addition, the ESM has certain advantages over observational methods for studying student experience. Observational methods provide ecologically valid data, but they are limited to overt behavior and cannot access internal affective states [6]. They are also relatively expensive, which makes them unsuitable for studying general trends in student experiences. In-the-moment experience data has been shown to both complement and disagree with more traditional global measures of experience [6]. Investigations of how people experience work and leisure found that work provided a richer activity with greater opportunity for success and growth than common leisure activities and yet was reported as much less enjoyable on global surveys [7]. While the ESM provides access to data not readily available from "traditional" methods, it is arguably most effective when combined with these methods as additional sources of information [6].

Participating in the ESM

Participation in the ESM is a 2-3 hour time commitment distributed over a one-week period. A short (~30-minute) training session is held the day prior to the start of data collection. In the training session, students learn how to use the watch and how to fill out the Experience Sampling Form (ESF) when signaled. The training session also provides an opportunity for students to complete additional surveys, as described in the section on the use of complementary measures.

Completion of the ESF takes approximately 90 seconds. Participants must complete a minimum of 15 ESF responses to provide a large enough sample to reliably represent their experience. To be included in the analysis, the ESF must be completed within 15 minutes of a response signal (in our study, the watch signal). This ensures that responses are about the event occurring at the signaled instant and not about a later event, thereby minimizing bias [1]. Following the week of data collection, participants complete a survey about how participating in the ESM affected their daily lives. Consistent with prior findings [1], participants in the present study indicated that the ESM had little to no impact on their day-to-day lives.

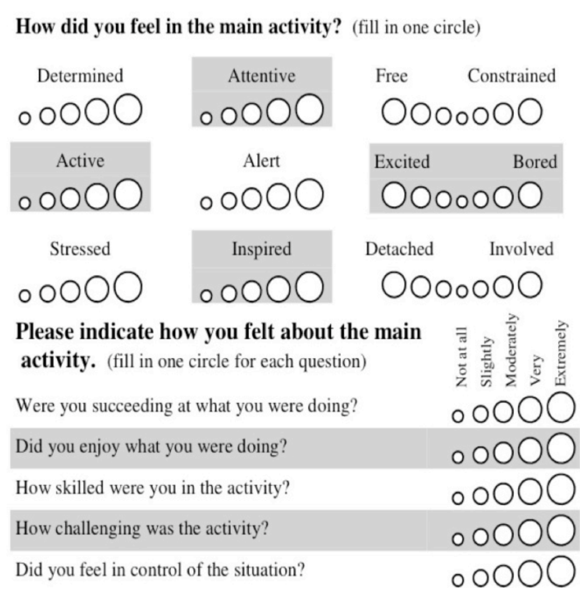
Fifteen undergraduate physics students at a state university participated in the study. Twelve of the participants, whose data were used to illustrate the use of ESM to study groups, were enrolled in one of two introductory calculus-based physics courses: a mechanics course offered in the fall and an electricity and magnetism course offered in the spring. Both courses were designed for engineering students. Participants were recruited via a short announcement in lecture. They were given extra credit for participating but received no other compensation. For the mechanics course, 16 participants completed the training and 9 completed the minimum number of surveys necessary for reliable data analysis. For the electricity and magnetism course, four students completed the training and all of them completed sufficient surveys. One of the 12 students participated in both semesters of data collection.

The participants differed from the overall course populations in two ways: (1) There were a disproportionate number of female volunteers, and (2) there were no students who failed to pass the course. Participants were, however, representative of the entire course population with respect to course grade (p=0.45) and performance on pre-semester conceptual inventories (p=0.26).

To illustrate the use of ESM to study individuals, data was also collected for three undergraduates acting as Learning Assistants (LAs) in the electricity and magnetism course. As in the model program developed at the University of Colorado [8], LAs collaborate with graduate teaching assistants in facilitating small-group tutorial instruction during two recitation periods each week. One of these students' data is presented in detail.

The Experience Sampling Form

The Experience Sampling Form (ESF) is comprised of both open-ended and Likert-scale questions (Fig. 1). The ESF for this study was adapted from those used in the Sloan Study of Youth and Reference [1]. The most important adaptation was the purposeful selection of Likert-scale ESM questions to ensure that a minimum of three questions targeted the following categories of experience: self-efficacy, intrinsic motivation, and activation.


How did you feel in the main activity? (fill in one circle)

Determined

Attentive

Free Constrained

Active

Alert

Excited Bored

Stressed

Inspired

Detached Involved

Please indicate how you felt about the main activity. (fill in one circle for each question)

Not at all, Slightly, Moderately, Very, Extremely

Were you succeeding at what you were doing?

Did you enjoy what you were doing?

How skilled were you in the activity?

How challenging was the activity?

Did you feel in control of the situation?

FIGURE 1. Selected items from the ESF illustrate Likert-scale questions that correspond to variables within activation, self-efficacy, and intrinsic motivation.

The open-ended component of the ESF includes four basic questions: (1) What is the main thing you are doing? (2) What else were you doing at the same time? (3) What was on your mind? and (4) Where were you? In this study, responses to questions about what the participant was doing and thinking were coded into three main activity categories: non-school activities, non-physics school activities, and physics school activities. The school activities were further broken down into five sub-categories: lecture, lab, recitation, homework, and other. These categories allowed for investigations of differences in experience between physics and non-physics courses and within the various components of the physics course itself.

In order to ensure that ESM measurements were made during physics instruction, watches were programmed to signal students at least once during each of the five scheduled class times for the different physics course components. All other signals were randomly distributed between 8 am and 10 pm.

The ESF contains 20 Likert-scale questions covering affective and cognitive experience. The questions were selected so that several of them pertain to each category of experience (Table 1). These groupings were confirmed using factor analysis on 468 completed surveys from all participants. Factor analysis revealed six categories of experience. Five of these categories (activation, self-efficacy, intrinsic motivation, affect, and cognitive efficiency) aligned with factors from previous studies. The discussion in this paper will be limited to three of these categories: activation, self-efficacy, and intrinsic motivation.

TABLE 1. Three highlighted categories of experience, along with their component variables. Internal consistency (α) and the total variance explained (VE) are reported for each category [9].

Activation	Self-Efficacy	Intrinsic Motivation
Determined	Skill	Free/Constrained
Attentive	Control	Excited/Bored
Alert	Succeeding	Detached/Involved
Concentrating	Active	Enjoyment
Challenge	Inspired	
α=0.80	α=0.61	α =0.71
VE=16.7%	VE=11.4%	VE=10.1%

In order to conduct a statistical analysis across individuals, ESM responses for each component variable are converted from a raw score to a Z-score that is based on the individual's overall experience [1]. Z-scores show how far a given score varies from a mean score in standard deviation units, and therefore center about zero and extend in either the positive or negative direction. By using within-person Z-scores, each individual's experience for a given variable is compared to his or her typical, or average, experience. Z-scores for the different categories of experience are generated by averaging over their component variables. In the present study, a student's (localized) self-efficacy in physics lecture, for instance, was compared using Z-scores to the average of his/her self-efficacies for all experiences recorded over the week.

Use of Complementary Measures

It is possible to investigate connections between student affective experience measured by ESM and other student outcomes, such as student achievement or attitudes. In the present study, ESM results were compared to data on: (1) conceptual learning, (2) attitudes and beliefs as measured by the Colorado Learning Attitudes about Science Survey (CLASS), and (3) global physics self-efficacy as measured by an adaptation of the Physics Self-Efficacy and Identity Survey.

Data Analysis for Groups

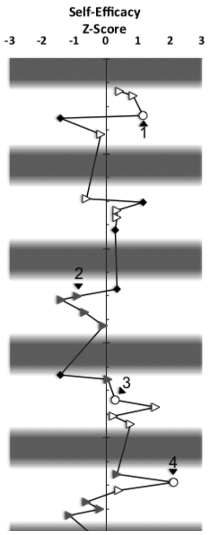
ESM Z-scores can be averaged across individuals within each activity category to create a single score for the activity representing the entire sample. In the present study, averages were created for experiences across three activity categories: physics, non-physics school, and non-school. Data from the two courses were analyzed independently. The results were statistically similar ($p>0.2$) and are therefore combined in Table 2 for the twelve participating students. Two important statistically significant differences ($p<0.05$) [10] emerged from this analysis. First, students had high positive activation in school activities, but at the same time had negative self-efficacy and negative intrinsic motivation. Second, students had lower self-efficacy in physics than in their non-physics courses.

TABLE 2. Z-scores for students' average experience.

Category	Activation	Self-Efficacy	Intrinsic Motivation
Physics	0.35	-0.65	-0.42
Non-Physics	0.36	-0.14	-0.28
Non-School	-0.35	0.30	0.27

MEASURING AN INDIVIDUAL'S EXPERIENCE

The ESM can add to the weight of evidence describing a single person's overall experience in a physics course. This point is illustrated by the case of one of the three LAs who differed markedly from all other participants in that he exhibited a high



	What is the main thing you are doing?	What else were you doing at the same time?	What was on your mind?
1	Listening to [Dr. X] go over [physics] homework problems.	I was thinking about interesting physics problems.	Calculus of variations, particularly wanting to get a feel for it.
2	Writing an essay on energy production. Particularly solar and its effects on the environment.	Thinking about fantasy RPG setting.	What do I have orcs do? Am I putting too much about fossil fuels?
3	Working on a fantasy setting [D&D].	Listening to [Dr. X] talk about [physics] homework.	Thinking about the history of a fictional war.
4	Talking about Hubble's Law and the expansion of the Universe	Nothing	How does Hubble's constant yield the age of the Universe?

KEY		
	▲ **Non-Physics Homework**	△ **Physics Homework**
	○ **Physics Lecture**	◆ **Non-School**

FIGURE 2. An example of one student's self-efficacy experience across five days with examples of open-ended response.

self-efficacy in his physics experience relative to other experiences (Fig. 2). His self-efficacy experience throughout a one-week period is shown in the graph. Fig. 2 also includes the student's written responses corresponding to the four numbered measurements in the graph. The graphs shows that his physics self efficacy tended to lie on the positive side of the axis. Notably, two of his most efficacious experiences were in physics lectures. The written responses for the lecture events show, in the first case, a desire to "get a feel" for the material, and in second case, a question possibly indicating his inclination to go deeper into the material. Complementary measures corroborate the ESM's identification of this student as being different from his peers. He was a sophomore in physics who also was as an LA for the introductory course. He had an exceptionally high level of conceptual understanding (93% on BEMA), expert-like attitudes (97% overall score on the CLASS), and high global self-efficacy within physics.

CONCLUSIONS

Efforts to access student in-the-moment experience should help guide course transformations by providing information about important outcomes that are not measured by traditional achievement and attitude instruments. Moreover, by combining in-the-moment data with that from traditional instruments, researchers and educators can begin to identify important predictors of valued outcomes, both for groups of students and for individuals. These predictors can, in turn, inform future course modifications.

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9. Shown variables have a loading >0.4 on the category (factor) and <0.25 cross-loading on other categories with the exception of control. Control loaded on self-efficacy (0.42) and intrinsic motivation (0.36) and was used in compiling self-efficacy based on prior research [1].
10. Statistical analysis completed using MANOVA.