Towards Automatically Detecting Whether Student Is in Flow

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Abstract. Csikszentmihalyi's flow theory states the components (e.g., balance between skill and challenge) that lead to an optimal state (referred to as flow state, or under flow experience) of intrinsic motivation and personal experience. Recent research has begun to validate the claims stated by the theory and extend the provided statements to the design of pedagogical interactions. To incorporate the theory in a design, automatic detector of flow is required. However, little attention has been drawn to this filed, and the detection of flow is currently still dominated by using surveys. Hence, within this paper, we present an automated detector which is able to identify the students that are in flow. This detector is developed using a step regression approach, with data collected from college students learning linear algebra from a step-based tutoring system.

Keywords: Student Modeling, Flow Theory, Educational Data Mining, Intelligent Tutoring System.

1 Introduction

Personal experiences are essential to pedagogical interactions. Hence, to improve personal experience, many studies have strived to increase the sensitivity and responsiveness of intelligent tutoring systems (ITSs) to various affects of students. On the other hand, Csíkszentmihályi's flow theory states the components that may lead to an optimal state (referred to as flow state, or under flow experience) of intrinsic motivation and personal experience [7]. When the flow theory is applied to education, numerous empirical studies on teaching, including teaching in high school classrooms by using traditional approaches (i.e. not ITS) [18, 19] and also teaching by using tutoring systems (TSs) [10, 14, 16], have reported that students engage in learning activities the most when they perceive both challenges and their skills as high.

The learning contents provided to students should be perceived as challenging yet not too difficult, for ensuring an optimal experience [18]. But in practice, learning

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contents are usually non-adaptive, which are likely to fail in producing flow for most students [17]. Because these learning contents that maintain at a specific difficulty level constantly may be monotonous for students with high skill, and frustrating for students with low skills. Fortunately, modern ITSs [20] that are capable of accurately identifying student's condition (e.g., competencies, emotion states, or flow), may be able to provide adaptive learning contents by selecting specific problems of appropriate properties to strike a balance between the perceived challenge and a student's skill level [7, 15]. However, despite the recent advances in affect detection and competencies detection, the development of automatic flow detector has been lack of attention. Hence, this study presents a flow detector designed to identify learners that are in the flow state, when interacting with a step-based TS for linear algebra (LA).

2 Method

2.1 Participants

The dataset was collected over a period of two months. Participants were 78 college students required to have a basic understanding of high-school algebra and not have taken any college-level linear-algebra courses. Each student took from two to three weeks to complete the study over multiple sessions. In total, 55 students completed the study.

2.2 Domain and Procedure

The step-based TS used in this study is called Tempranillo. Within Tempranillo, students complete LA problems and are formatively assessed based on a knowledge component (KC) model, providing information about their knowledge to their teachers, while being assisted with scaffolding, help, and feedback.

Our work used the "linear transformations" and the "orthogonality" of LA domain as covered in the first-year college LA course. The fifteen primary KCs were: Definition of Linear Transformation (KC1), Definition of Kernel (KC2), Definition of Image and Range (KC3), Theorem 4.2.1 in [12] (KC4), Theorem 4.2.4 in [12] (KC5), Similarity (KC6), Definition of Distance Between X and Y (KC7), Theorem 5.1.1 in [12] (KC8), Cauchy-Schwarz Inequality (KC9), Orthogonality (KC10), Scalar and Vector Projections (KC11), Orthogonal Complement (KC12), Fundamental Subspaces (KC13), Theorem 5.1.1 in [12] (KC14), $W = U \oplus V$ (KC15).

All participants experienced an identical procedure and presented with same materials. The procedure was as following: 1) a background survey; 2) read a textbook covering the target domain knowledge; 3) took a pretest; 4) solved the same fifteen training problems in the same order on Tempranillo; and 5) took a posttest. The pretest and posttest were identical. A KC-based score for each KC application was given by identifying all relevant KCs over all test questions. In the following sections, the evaluation of the competence of each student is provided based on the sum of all of these KC-based scores. The tests contained 36 test questions which cover 41 KC occurrences. All test scores were normalized to fall in the range of [0,1] for comparison purposes.