An Adaptive Spelling AI System For Personalized Dutch Spelling Education

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In the Netherlands, 35% of 15-year-old students today fail to attain the basic Dutch reading level and are even at risk of leaving education with inadequate literacy skills [2]. To address the declining literacy proficiency under students, this thesis presents the development of an adaptive Dutch spelling AI system that automatically generates spelling exercises tailored to the learning gain of primary school students. The uniqueness of this approach lies in its departure from the conventional dataset formation approaches [4, 6]. Previous research has focused on assessing word complexity through human assessors or by correlating word frequency with word complexity. By providing new insights into the reliability and effectiveness of morphological features and syntactic structures in determining word complexity, this study proposes a potentially more reliable and consistent approach for assigning spelling complexity scores. This method automates the creation of word complexity datasets, as opposed to human assessors, which can enhance adaptive systems by expanding their range of exercises to better match each student's proficiency level, thereby potentially increasing the overall effectiveness of personalized learning experiences.

To adequately generate exercises to a student's proficiency level, the degree of spelling difficulty of individual words was established through syntactic structures and morphological features of the Dutch language. A spelling complexity algorithm was then developed, utilizing reference frameworks of Cito, SLO and the CED group, in order to assign spelling complexity scores to a dictionary of 200.000 words of *Stichting OpenTaal* [1]. This algorithm integrates the assigned complexity scores with loanword detection and additionally applies a penalty based on the number of syllables. To evaluate whether the degree of spelling difficulty of individual words could be determined by syntactic structures and morphological features of the Dutch language, words from Cito exams of mid-year assessment periods in grades three to eight were compared to the assigned word complexity scores of the developed algorithm. The results showed an overall increase in difficulty as the grade level advanced, which aligned with the hypothesis that Cito exams for higher grades have a higher average word complexity score than words of lower grades. Additionally, the created word complexity algorithm was evaluated by comparing its rankings with participants' perceived difficulty rankings through a survey. The rankings for the sets containing intermediate and large step sizes showed a very strong correlation between human perception and the developed word complexity algorithm, according to the Spearman's rho

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values and the T-test. Sets containing small and random step sizes predominantly showed a statistically insignificant correlation, which is likely due to the challenge of discerning subtle differences [3, 5].

An adaptive spelling AI system has then been created through a refined Elo rating system augmented by additional parameters which dynamically adjusts the difficulty of spelling exercises based on individual user performance. In addition, this system is capable of accounting for various types of Dutch spelling errors. This algorithm matches a user with a suitable spelling exercise, taking into account the pre-event rating, the number of questions attempted and answered correctly, the number of occurred spelling rules, and the total number of successfully answered spelling rules. Furthermore, this system utilizes a dynamic uncertainty function and an expected score, indicating the probability that a user will successfully solve the given exercise. To accurately detect and evaluate user input errors, the Needleman-Wunsch alignment algorithm was utilized in combination with a sophisticated mechanism for detecting and accounting for user input errors. Two experiments have been conducted to evaluate the effectiveness of this algorithm. In these experiments, different types of students exhibiting various spelling error patterns and spelling deficiencies have been simulated. The first experiment demonstrated that students exhibiting fewer spelling errors correlate with higher user ratings, thus showing the algorithm's ability to dynamically adjust difficulty levels based on individual user performance. The second experiment evaluated whether the developed adaptive learning system could capture spelling deficiencies within the average attention span of a primary school student and thus account for various spelling errors. This ensures a more accurate reflection of a student's true ability, minimizing the impact of careless mistakes, which increases when attention wanes. The results showed the system's effectiveness in capturing each deficiency within the average attention span of a primary school student.

Although this system shows capabilities in capturing various spelling deficiencies and error patterns, it has limitations in highlighting phonetic spelling discrepancies. The generalizability of the results is furthermore limited by simulated students exhibiting different error patterns and spelling deficiencies. Future research and field-testing could expand the scope and applicability of the results. Testing the developed algorithm across multiple classrooms with a sufficient number of primary school students would provide a more accurate and comprehensive overview, potentially offering valuable insights for improvements. Students may reveal the effects of random errors and various unpredictable spelling deficiencies on the system. Finally, adding a profile assignment to each student utilizing the adaptive spelling AI system, would allow for data-driven insights into a student's progress, including areas that require improvement.

With the unique combination of the refined Elo rating system augmented by additional parameters, the Needleman-Wunsch alignment algorithm, and a sophisticated mechanism for detecting and accounting for user input errors, this research seeks to extend and possibly improve the domain of existing adaptive learning systems through the application of explainable AI.

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