PhysWikiQuiz - An AI-Aided Collaborative Physics Exam Question Generation and Test System for Teachers and Students

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Abstract

We present »PhysWikiQuiz«, a physics question generation and test engine. Our system, hosted by Wikimedia, utilizes Wikidata, an open, community-managed database, to acquire physics knowledge. For the teacher's input of a given concept name, it produces personalized questions for each individual student. Subsequently, it uses a Computer Algebra System (CAS) to check the correctness of student answers, in both value and units.

With the rising adoption of digital learning platforms, teachers are progressively creating tasks and questions digitally [11]. However, it can be a laborious task for a teacher to constantly create novel and individual questions for each student [3]. Artificial Intelligence (AI) helps to generate tests more frequently, which can lead to improved student performance [4]. Furthermore, when teachers create exam questions, they often do not exchange ideas or materials with other teachers, thereby making the task of building questions inefficient [2]. To address this, the open semantic knowledge base Wikidata[1] can be used as a multilingual framework that allows for collaborative worldwide teacher knowledge engineering and subsequent AI-generated question generation, testing, and correction. As a proof of concept for the physics domain, we present our »PhysWikiQuiz« teacher question generation and student answer test engine. The system is hosted by Wikimedia[2] with available open source code[3], a comprehensive

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[1]https://www.wikidata.org
[2]https://physwikiquiz.wmflabs.org
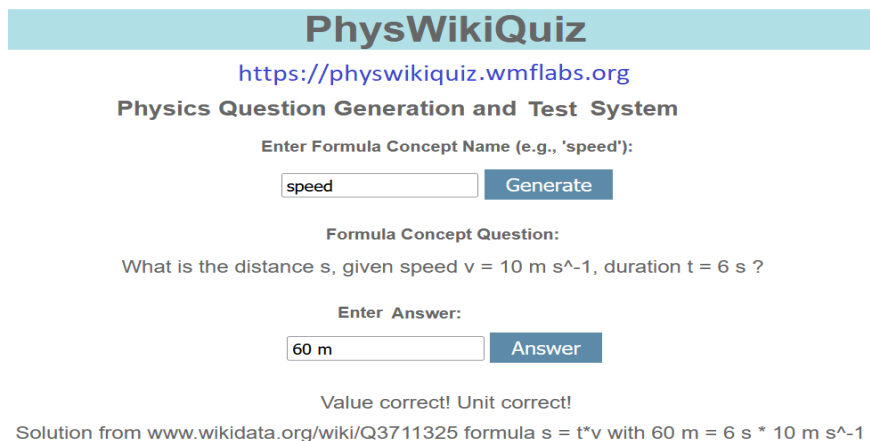[3]https://github.com/gipplab/PhysWikiQuiz

Figure 1: Example question generation, answer correction, and explanation display.

demonstration video[4], and an API for integration in external education systems or platforms. Figure 1 shows an example workflow for the formula concept [7, 9] 'speed'[5], including question generation (top), answer correction (center), and solution explanation (bottom). The module workflow is the following: **Module 1** retrieves formula and identifier information from Wikidata for a given knowledge concept. In the shown example, the 'defining formula' property is $v = s / t$, and the identifiers are distance s, speed v, and duration t. **Module 2** generates various possible algebraic formula rearrangements [10, 1], such as for the example $s = v * t$ or $t = s / v$. **Module 3** generates random numerical values for the variables in the question (e.g., $v = 10$ m/s and $t = 6$ s) and calculates the numerical value for the answer (in this case $s = 60$ m). **Module 4** generates a well-structured question in natural language by using the variables' available names, symbols, and values. **Module 5** checks the answer value and unit entered by the student and displays a correctness assessment. **Module 6** generates an explanation text with the formula (including source) and a calculation path for the student's understanding. For more detailed explanations and a comprehensive evaluation resulting in the derivation of challenges, see the README of the code repository[3]. Wikidata contains a rapidly growing number of currently around 6,000 statements that link an item concept name to a formula [5, 6]. This leads to a very large question coverage, which can collaboratively be extended by teachers. For a given concept, PhysWikiQuiz can generate an unlimited amount of questions substituting unbounded random variable numbers. The system can be integrated into larger education platforms via the provided API to work seamlessly with any chosen Learning Management System (LMS).

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[4]https://purl.org/physwikiquiz
[5]https://www.wikidata.org/wiki/Q3711325

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