
Investigating the Use of Hints in Online Problem Solving

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Abstract

We investigate the use of hints as a form of scaffolding for 4,652 eligible users on a large-scale online learning environment called Isaac, which allows users to answer physics questions with up to five hints. We investigate user behaviour when using hints, users' engagement with *fading* (the process of gradually becoming less reliant on the hints provided), and hint strategies including *Decomposition*, *Correction*, *Verification*, or *Comparison*. Finally, we present recommendations for the design and development of online teaching tools that provide open access to hints, including a mechanism that may improve the speed at which users begin fading.

Author Keywords

Problem Solving; Scaffolding; Hints; Physics

ACM Classification Keywords

K.3.1 [Computer Uses in Education]: Distance learning

Overview

Supporting distance learners can be difficult. Lack of geographic and temporal co-location reduces opportunities for timely feedback and tailored interventions, making it difficult for students to sustain motivation. This reduces the efficacy of Massive Open Online Courses in particular.

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Teaching effective problem solving strategies or heuristics is a common educational goal and is documented across various disciplines, particularly those considered more mathematical in nature [3, 2]. Teaching these skills is not trivial, and can be demanding in terms of cognitive load [1], making supporting the development of such skills in a distance learning context particularly difficult.

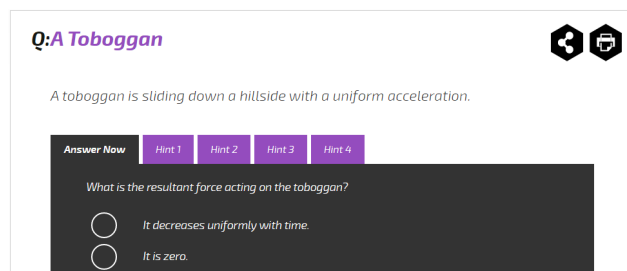


Figure 1: Typical hint layout to a question

Teachers often provide prompts or questions, referred to as scaffolding, to support inexperienced problem solvers. The Isaac platform provides a novel scaffolding mechanism that supports learners of physics at a large scale by providing a structured approach using hints that helps to decompose the problem. The steps in this mechanism consist of (1) Identify the questions goal and pertinent info, (2) Draw a Diagram (3) Identify useful concepts and tools, (4) Plan and implement your solution on paper, and (5) Check your working. Five hint types have been developed and used on Isaac to encourage these steps (see Figure 1). This paper presents early instrumentation data that shows students' use of hints during problem solving.

Method

We identified the following research questions: (1) How do people use hints to scaffold their learning? (2) What

impact do using hints have on student success? (3) How do motivations for the use of hints differ between users? (4) To what extent do users voluntarily engage with fading? The data presented in this paper is based on usage log data and was collected between 20/09/2014 and 21/09/2015, and is derived from instrumentation logging. We exclude any data generated by known teachers and project staff. In our analysis, we make the assumption that users who view hints receive benefit from it, and therefore may behave differently from those who have not. We therefore track users' usage of hints across all sessions on the site. Approximately 74% of hints, or 679/908, of eligible questions follow the hint sequence strictly. Hint views are recorded when a user clicks on a hint tab, making it possible for multiple hint views per question or skipping hints entirely.

Results

Of the 4,652 users that answered a question, 456 always used all hints available on every question, 3,673 used at least some of the available hints on some of the questions, and 523 never used hints on any question. A total of 185,896 hint views were recorded over 816 questions of the 908 eligible questions where hints are available. Isaac contains 64 questions where every user attempting has viewed all the hints available, suggesting they are challenging. In total, there were 752 questions on which users used at least one hint. For each question where hints were used, a median of one user-hint was viewed.

Patterns in Hint Usage

Table 1 shows pairs of events within our users' *question interactions*. The shading highlights patterns of hint usage; for example 58% of people who view a Concepts hint then view the Info hint; 34% of people who view the Info hint view the Diagram hint and so on.

		Subsequent Event								Total
		End	Correct	Incorrect	Concepts	Info	Diagram	Equations	Video	
Event	Start	0.0	39.0	33.0	20.0	1.9	1.1	1.7	2.7	100
	Correct	90.0	5.6	0.62	1.8	0.32	0.35	0.48	1.0	100
	Incorrect	2.4	16.0	64.0	7.3	1.6	1.1	2.0	4.9	100
	Concepts	4.1	5.1	12.0	7.5	58.0	5.0	4.5	4.0	100
	Info	1.7	3.6	9.3	14.0	7.1	34.0	24.0	6.0	100
	Diagram	3.1	4.0	8.6	7.2	14.0	7.4	44.0	11.0	100
	Equations	3.1	4.3	10.0	9.0	15.0	15.0	7.4	36.0	100
	Video	8.5	11.0	25.0	12.0	5.6	5.2	19.0	13.0	100

Table 1: Percentage likelihood of users carrying out one event (column) after a given previous event (row). The table should be read row-wise only. (For example, for those users that enter an incorrect answer, 7% subsequently view a concept hint.

With user interactions of any length (i.e. not just those shown in Table 1), if we denote correct answers with ✓, incorrect with X, and hints with Concepts, Information, Diagrams, Equations and Videos, the top 5 most frequent patterns were, in descending order, (1) C → ✓, (2) C (3) C → I → ✓, (4) C → I → D → E → V (5) V → ✓.

The most common strategy is to view the concept hint for problem decomposition and then submit a correct answer. The second is to use the concepts hint to determine if the question can be answered; a large proportion of users do this and never attempt to answer. The fifth top strategy – viewing the video without any other hints and answering correctly, may have been due to students learning which hints suit them best. While this may be evidence that some students do not follow our hint sequence, they have followed the steps independently, or simply opted to view the hint they perceive to be most valuable immediately. However, absolute data (on which Table 1 is based, but does not include) shows that viewing a video hint is

the most likely hint to lead to a correct answer (0.9% compared with 0.47 0.35 0.26 0.38 for concepts, info, diagram and equations respectively), which indicates that users are not always using the hint that is most likely to lead to a correct answer. Even so, not all users viewed the video hints — this could be due to a number of factors (e.g. bandwidth, time required, school network restrictions).

Motivation for hint use

We have identified 4 different motivations for using hints: Decomposition, Correction, Verification and Comparison.

Decomposition

The user is unable to make a start and needs support decomposing it into solvable chunks. On Isaac, such students can be identified as those who do not answer before looking at the hints, or perhaps only use the hints that perform this initial decomposition activity for them. The data shows that this strategy is used by a high proportion of users: 3,086 of 4,652 (66.34%).

Correction

Further help is needed in response to an incorrect answer being received. The data shows that of the users who submitted incorrect answers, a high proportion viewed hints afterwards: 3,196 of 3,984 (80.22%). When a user is told they have provided an incorrect answer, Isaac attempts to provide them with tailored feedback if the answer is associated with a common error and therefore may provide sufficient support for the 788 users for whom no further hints are required.

Verification

The user has calculated an answer and wants to verify it before submitting. An early usability study of Isaac helped to identify this behaviour by finding that at least one student viewed hints after entering the correct answer but before pressing the 'check answer' button. Users who engage in this behaviour may be relying on scaffolding when it is not needed; this is a supporting case for enforced fading of the hints to take place. To develop effective problem solving skills we would prefer that users verify the correctness of their solutions themselves without relying on expert hints. Unfortunately, we are unable to accurately quantify the number of users who hold this motivation due to the many ways it could manifest. For example, users may calculate an answer on paper before using the hints.

Comparison

The user has already given a correct answer but wishes to compare the process used by an expert to their own by subsequently using hints. The data shows that this strategy is used by a moderate proportion of users who answered questions correctly: 1,179 of 4,075 (28.93%). This is an encouraging behaviour to observe as it is important to become familiar with different strategies of problem solving.

Future Work

We intend to investigate the popularity of different hint types by changing how we present hints to users so that we can observe which types are the most popular. As part of this future work we will more directly investigate how question difficulty affects how users use the scaffolding available.

Currently, Isaac supports the use of multiple choice and numeric questions. We are in the process of incorporating additional tools to support the entry, and automated assessment, of formulae as a new question type. This will allow students' to solve problems algebraically rather than numerically, which is an abstraction that is known to be challenging for physics students [2].

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