Help Seekers vs. Help Accepters:

Understanding Student Engagement with a Mentor Agent

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Abstract. Help from virtual pedagogical agents has the potential to improve student learning. Yet students often do not seek help when they need it, do not use help effectively, or ignore the agent's help altogether. This paper seeks to better understand students' patterns of accepting and seeking help in a computer-based science program called Betty's Brain. Focusing on student interactions with the mentor agent, Mr. Davis, we examine the factors associated with patterns of help acceptance and help seeking; the relationship between help acceptance and help seeking; and how each behavior is related to learning outcomes. First, we examine whether students accepted help from Mr. Davis, operationalized as whether they followed his suggestions to read specific textbook pages. We find a significant positive relationship between help acceptance and student post-test scores. Despite this, help accepters made fewer positive statements about Mr. Davis in the interviews. Second, we identify how many times students proactively sought help from Mr. Davis. Students who most frequently sought help demonstrated more confusion while learning (measured using an interaction-based ML-based detector); tended to have higher science anxiety; and made more negative statements about Mr. Davis, compared to those who made few or no requests. However, help seeking was not significantly related to post-test scores. Finally, we draw from the qualitative interviews to consider how students understand and articulate their experiences with help from Mr. Davis.

Keywords: Help Seeking, Help Acceptance, Pedagogical Agents

1 Introduction

Despite the growing body of research on the relationship of help seeking with various student characteristics (e.g., prior knowledge, self-regulatory skills, demographic characteristics) and learning outcomes in computer-based learning environments (CBLEs), we do not yet fully understand how all of these variables interact [1–3]. In particular, we still do not understand which factors lead students to accept help when it is initiated by the system (rather than by the student), and the conditions under which accepting such help contributes to better learning [4]. We also do not understand the degree to which help acceptance and help seeking are related behavioral patterns [1].

The present study takes up these questions by investigating patterns of help acceptance and help seeking in a CBLE for science called Betty's Brain [5]. Many CBLEs, including Betty's Brain, offer help to learners. Such help can take the form of hints, reflection prompts, or directions to relevant information [1]. In some cases, CBLEs diagnose learners' needs and deliver unsolicited assistance, however, there are also situations where help must be proactively sought by the learner.

As in traditional classrooms, seeking help effectively in CBLEs requires cognitive and metacognitive skills [6]. Thus, there is a risk that students who stand to benefit most from the system's help may be least equipped to seek and apply it. Early studies found that students with less prior knowledge were not well-equipped to self-diagnose gaps in their knowledge [7]. Similarly, [8] found that low-performing students often ended their conversation with the mentor agent immediately after being asked what kind of help they needed, which may indicate that they were struggling to identify and articulate the gaps in their understanding [8].

Help seeking is not uniformly beneficial. For example, help seeking can be counterproductive to learning when students are overly reliant on high-level help [9], or when they game the system [10]. In contrast to the predictions of prior help-seeking theories and models, [11] found that avoiding help was associated with better learning than seeking help on steps for which students had low prior knowledge of the relevant skills. The relationship between help seeking and performance has also been found to vary across school demographic contexts [3]. Specifically, [3] found that higher hint usage was associated with higher math performance in urban schools but associated with lower math performance in suburban/rural schools. Other demographic categories (e.g., schools with high or low numbers of economically disadvantaged or limited English proficiency students) also showed differences.

Compared to proactively seeking help, accepting help prompted by the system requires less initiative from the student. Even so, struggling students may lack the knowledge or skills to respond productively after receiving system-initiated help. A recent study suggests that anxiety may inhibit frustrated students from accepting help delivered by a mentor agent [12]. This study used interviews to understand how trait-level science anxiety shaped students' behaviors after experiences of frustration; they reported that students with higher anxiety "seemed unable to process the help they were given" by the mentor agent, whereas less anxious students were more receptive.

Understanding the factors that lead students to accept system-initiated help is important because there is evidence that help acceptance is positively correlated with learning. [4] found that the degree to which students accepted a pedagogical agent's offer to provide help was a stronger predictor of learning gains than was their standardized test score. In this study, positive correlations to learning gains were seen both for students' willingness to receive advice from the pedagogical agent, and their actual compliance with the agent's advice.

This paper seeks to clarify the relationship between help acceptance, help seeking, and learning by identifying (a) student characteristics and experiences associated with help acceptance and help seeking, (b) whether there is an association between students' patterns of help acceptance and help seeking, and (c) how help acceptance and help seeking are related to learning outcomes. To do so, we combine interaction log and *in-*

situ interview data collected from a sample of middle school students who used the Betty's Brain computer-based learning environment to learn about climate change. Betty's Brain offers an ideal setting to examine help acceptance and help seeking in tandem because it includes a mentor agent, Mr. Davis, who both initiates assistance and responds to student-initiated requests. Focusing on students' interactions with Mr. Davis, we examine how patterns of help seeking and help acceptance are related to one another; student characteristics and experiences while learning; and post-test scores. Finally, we complement these quantitative findings by using previously-collected interviews to consider how students themselves experience and describe their interactions with Mr. Davis.

2 Mr. Davis and Betty's Brain

In Betty's Brain [5], students construct a visual causal map that represents the relationships in complex scientific processes (i.e., climate change). Students use this map to teach a virtual agent named Betty. Students can gain information about the topic by reading the science resources book; learn strategies for teaching causal reasoning by reading the teacher's guide; check Betty's understanding by asking her questions; and evaluate their progress by having Betty take a quiz. Throughout these activities, the mentor agent Mr. Davis is available to provide on-demand help. Mr. Davis is presented to students as an experienced teacher whose role is to mentor them in the process of teaching Betty. Mr. Davis also grades Betty's quizzes and offers suggestions for ways to improve. His advice includes evaluations of the accuracy of the students' causal map links and suggestions to read specific pages in the science resources book or teacher's guide that contain the information necessary to fix incorrect links [13].

3 Methods

3.1 Participants

Data was obtained from a previously published study [14]. The data for this study were originally gathered from 92 sixth-grade students at an urban middle school in Tennessee, who spent four days (approx. 50 min/day) using Betty's Brain to learn about climate change in December 2018. The school has a diverse student population, with 60% White, 25% Black, 9% Asian, and 5% Hispanic students, and 8% of students enrolled in the free/reduced lunch program. The individual demographic information of the students was not collected. Throughout the unit, multiple forms of data were collected on the students' activity, experiences, and performance. After dropping 4 students who did not complete the anxiety survey from our analysis, our sample size was 88.

3.2 Interaction Log Data

Betty's Brain recorded the students' computer activity as interaction log data, which allows us to analyze various aspects of their virtual interactions, including the reading

suggestions they received from Mr. Davis, whether they visited the pages he suggested, and the number of times each student initiated a conversation with Mr. Davis.

Help Acceptance. We operationalized help acceptance as a binary variable indicating whether a student ever followed Mr. Davis' reading suggestions. We consider the help to have been accepted if a student visited the page indicated by Mr. Davis in the period between the time that page suggestion was delivered and Mr. Davis' next page suggestion. We use a binary variable rather than a proportion because almost half (42%) of the students in the sample never followed a single page suggestion.

Help Seeking. For help seeking, we created an ordinal variable based on the total number of times each student began a conversation with Mr. Davis: low requesters (0-1 help requests), moderate requesters (2-4 requests), and high requesters (5-7 requests). The low and high request groups roughly correspond with the lowest and highest quintile of requests, respectively.

Affective States. The interaction log data also enabled the tracking of students' affective states while using the program, using detection algorithms that had already been integrated into Betty's Brain [15]. The affect detectors for each of five epistemic emotions (boredom, confusion, engaged concentration, delight, and frustration) each generated predictions (probabilities between 0 and 1) of the student's affective state every 20 seconds based on their activity in the program. In the following analyses, we average the affective probabilities at the student level across each student's entire history of interaction with the learning system.

3.3 *In-situ* Interviews

Additionally, members of the original research team conducted 358 short, *in-situ* interviews with students while they were participating in the program, gathering qualitative data about their experiences. Real-time monitoring of affective and behavioral sequences through an application called Quick Red Fox was used to prompt interviews, enabling the interviewers to delve into the cognition associated with crucial learning moments and changes in students' emotional states (see [16, 17]). The interviews were recorded, manually transcribed, and qualitatively coded (see [14] for details about the coding procedure). In the following analysis, we use variables indicating the proportion of interviews for each student that contained (a) positive and (b) negative statements about Mr. Davis [17].

3.4 Learning and anxiety measures

Student learning was assessed using pre- and post-test measures administered within the system, with a possible maximum of 18 points on each (see [18]). Additionally, trait-level science anxiety was measured using a revised version [12] of the Math Anxiety Scale [19]. The questions were modified to focus on science rather than math and

were designed to elicit students' thoughts and feelings about science in general, not just their experiences in the current learning environment.

4 Results

In this paper we explore both the more passive construct of help acceptance and the more active construct of help seeking. For both help acceptance and help seeking, we discuss how the behavior measured is predicted by students' pre-test score, science anxiety, and affective states while learning, as well as how it is associated with students' perceptions of Mr. Davis. Finally, we analyze how both help acceptance and help seeking are related to learning outcomes. Using the help acceptance and help seeking measures previously constructed, we predict post-test scores among students.

4.1 Help Acceptance

To determine which students accepted help from Mr. Davis, we first identified the number of times each student followed Mr. Davis' suggestion to read a specific page in the science textbook or teacher's guide. Overall, we found that help acceptance was uncommon: on average, students followed help recommendations 6.33% of the time (*SD = 0.093*). Further, 42% of students never followed Mr. Davis' reading suggestions and even the most compliant student only followed 50% of the reading suggestions they received.

We then examine student-level factors—pre-test scores, trait-level science anxiety, and average incidence of affective state while learning—that might predict whether students followed Mr. Davis' reading suggestions. Using binary logistic regression, we estimate the log odds of students ever accepting help versus never accepting help (Table 1). None of the student characteristics or affective states we examined were significant predictors of help acceptance.

Table 1. Binary Logistic Regression Predicting Help Acceptance

	***b* (*SE*)**	***p*-value**
Pre-test Score	-0.003 (0.093)	0.976
Science Anxiety	0.022 (0.029)	0.455
Boredom	-2.282 (4.488)	0.611
Engaged Concentration	-1.545 (4.460)	0.729
Frustration	4.866 (3.025)	0.108
Confusion	-0.396 (3.183)	0.901
Delight	12.553 (13.948)	0.368
Constant	-10.121 (10.580)	0.339
N	88	
AIC	129.23	

Next, we examine how help acceptance was related to help seeking and students' perceptions of Mr. Davis using two-tailed T-tests (Table 2). Comparing the means for each group (help accepters vs. non-accepters), we find that help accepters made on average 4.4% fewer positive statements about Mr. Davis than non-accepters *(t*(39.37) = 2.042, $p = 0.050$). The difference in the mean number of conversation requests was not statistically significant between help accepters and non-accepters ($t(75.098) = -0.374$, $p = 0.710$). Finally, there was no statistically significant difference in the means for negative perceptions of Mr. Davis between help accepters and non-accepters ($t(83.071) = -0.132$, $p = 0.896$).

Table 2. T-Tests Comparing Means of Help-Seeking and Perceptions of Mr. Davis by Help Acceptance

	Never Accepted Help	Ever Accepted Help	Mean Difference	*t*	*p*-value
Conversation requests	2.892	3.039	-0.147	-0.374	0.710
Negative Davis comments	0.093	0.098	-0.005	-0.132	0.896
Positive Davis comments	0.050	0.007	0.044	2.025	0.050
N	88	88	88	88	88

4.2 Help Seeking

Next, we examine how many times each student initiated a conversation with Mr. Davis—a form of proactive help seeking behavior. We find that 93% of students used this function at least once, indicating that most of the class knew the feature was available. We use an ordinal variable to measure help seeking (low requesters, moderate requesters, and high requesters), as discussed above. On average, students made 2.977 conversation requests over the course of the unit ($SD = 1.800$).

Using ordinal logistic regression, we predict help seeking using the same student-level characteristics examined for help acceptance: pre-test score, science anxiety, and the five affective states in Table 3 [20]. In contrast to the findings for help acceptance, we found that help seeking was significantly associated with both science anxiety and confusion. A one point increase in a student's anxiety level is associated with an increase in the tendency towards higher help requests ($\beta = 0.071$ ($SE = 0.029$, $p = 0.014$)). A student being confused also corresponded to a $\beta = 6.400$ increase in the tendency towards higher help requests ($SE = 3.050$, $p = 0.036$). However, a student's level of help seeking was not statistically significantly associated with pre-test score or the other four affective states.

Table 3. Ordinal Logistic Regression Predicting Help Seeking

	b (*SE*)	*p*-value

Pre-test Score	-0.008 (0.089)	0.933
Science Anxiety	0.071 (0.029)	0.014
Boredom	6.543 (4.481)	0.144
Engaged Concentration	-5.813 (4.213)	0.168
Frustration	-3.936 (2.890)	0.173
Confusion	6.400 (3.050)	0.036
Delight	-5.303 (11.408)	0.642
Low|Moderate	-2.625 (8.962)	
Moderate|High	0.544 (8.946)	
N	88	
Log-Likelihood	-76.42	
AIC	170.84	

Finally, we perform a series of bivariate OLS regressions to examine how help seeking is related to help acceptance and students' perceptions of Mr. Davis (Table 4).

Table 4. OLS Regression Coefficients Predicting Help Acceptance and Perceptions of Mr. Davis using Help Seeking Behavior

	Moderate Requesters		**High Requesters**		**Constant**	
	b (*SE*)	*p*-value	*b* (*SE*)	*p*-value	*b* (*SE*)	*p*-value
Reading compliance	-0.037 (0.025)	0.143	-0.029 (0.031)	0.363	0.091 (0.021)	< 0.001
Negative Davis comments	-0.018 (0.048)	0.716	0.142 (0.061)	0.023	0.081 (0.041)	0.055
Positive Davis comments	0.001 (0.024)	0.966	-0.011 (0.031)	0.728	0.026 (0.021)	0.207
N	88		88		88	

Regarding students' perceptions of Mr. Davis, we find that high requesters made 14.2 percent more negative statements about Mr. Davis in the interviews on average (*SE* = 0.061), compared to low requesters (the reference group) (p = 0.023). The moderate request group made the fewest negative statements, but the difference between the low and moderate request groups was not statistically significant (β = -0.018, *SE* = 0.0483, p = 0.7158). As Table 4 demonstrates, there were no significant relationships between help seeking and positive perceptions of Mr. Davis.

4.3 Learning Outcomes

Are patterns of help acceptance and help seeking related to learning outcomes in Betty's Brain? To examine this, we consider whether (a) the student ever accepting help from Mr. Davis or (b) the frequency of seeking help from Mr. Davis is associated with post-test scores. We use OLS regression to predict post-test scores beginning with a simple model including only pre-test scores as a baseline, followed by models including our key independent variables (i.e., help acceptance and help seeking, measured categorically as stated above) and student-level characteristics: science anxiety, the five affective states, and positive and negative perceptions of Mr. Davis (Table 5).

Table 5. OLS Regression Coefficients Predicting Post-Test Scores

	***b* (*SE*)**	***p*-value**
Pre-test Score	0.733 (0.110)	< 0.001
Help Acceptance	1.146 (0.583)	0.053
Help Seeking		
Moderate	0.379 (0.716)	0.599
High	0.389 (0.945)	0.683
Science Anxiety	-0.052 (0.036)	0.151
Boredom	13.939 (5.454)	0.013
Engaged Concentration	-2.584 (5.239)	0.623
Frustration	-6.669 (3.653)	0.072
Confusion	1.109 (3.756)	0.769
Delight	-2.435 (15.623)	0.877
Negative Davis Comments	-2.636 (1.525)	0.088
Positive Davis Comments	1.145 (3.306)	0.730
Constant	10.467 (11.759)	0.376
N	88	
R2	0.4457	

Across models, pre-test score remains the strongest predictor of post-test score. Controlling for other factors, a one point increase in pre-test score corresponds to an increase in the post-test score by close to three-quarters of a point ($\beta = 0.733$, $SE = 0.110$, $p < 0.001$). Further, we find that help-acceptance is marginally related to post-test score after controlling for the other student-level measures. Students who accept help score $\beta = 1.15$ points higher on average than those who did not ($SE = 0.583$, $p = 0.053$). However, neither moderate ($\beta = 0.379$, $SE = 0.716$, $p = 0.599$) nor high ($\beta = 0.389$, $SE = 0.949$, $p = 0.683$) help seeking are significantly associated with post-test scores.

4.4 Insights from Qualitative Interviews

The results above suggest that students who use Mr. Davis the most appear to like him the least. Why is this the case? This is a particularly curious finding, given that students who accepted Mr. Davis's help also learned more (though we do not have evidence that this relationship was causal – it might also have been selection bias). To shed light on students' perceptions of Mr. Davis, we turned to the qualitative interviews.

One possible explanation is that students who use Mr. Davis the most have higher expectations for the help he should be providing and are thus dissatisfied with the level of support received. For example, one student who both accepted and sought help from Mr. Davis suggested that Betty's Brain could be improved if the developers "let Mr. Davis help a little more." This student expressed frustration that Mr. Davis did not provide more explicit guidance, explaining that "when I ask Mr. Davis [about a cause-and-effect relationship], he always says that I'll have to figure it out on my own."

Relatedly, if students seek help from Mr. Davis but are unable to understand or use his assistance effectively, they may direct their negative feelings towards him. For example, one high requester reported that he "started a conversation with Mr. Davis and [Mr. Davis] told me that I was wrong, and so I got confused." If help seeking produces further confusion rather than clarity, students may harbor negative feelings toward the person they asked for help.

5 Conclusions

This study aimed to advance understandings of the relationship between help seeking, help acceptance, and learning. Our results indicate that help acceptance and help seeking are distinct behavioral patterns within Betty's Brain: help acceptance was not significantly associated with help seeking in our sample. And whereas science anxiety and confusion were associated with an increased likelihood of being a high help requester, these measures did not predict help acceptance. Finally, while help acceptance was a marginally significant predictor of improved performance (observed as higher post-test scores), help seeking was not associated with learning outcomes.

Even so, we see a key point of similarity regarding help accepters' and help seekers' perceptions of Mr. Davis: we observed negativity toward Mr. Davis among the students who had the most interaction with him. In terms of help acceptance, students who followed Mr. Davis' reading suggestions made fewer positive statements about Mr. Davis than those who never followed his reading suggestions. In terms of help seeking, the highest requesters made more negative statements about Mr. Davis than low requesters. The interviews tentatively suggest that negativity toward Mr. Davis may stem from a desire for more guidance and/or the student's inability to respond productively to his assistance. We also found that negative perceptions of Mr. Davis were associated with lower post-test scores, net of help seeking, help acceptance, and all other variables.

This study has several limitations. First, the study's sample size was relatively small, and involved only a single school. Second, although previous research demonstrates that academic help-seeking patterns are associated with student demographic charac-

teristics [1, 21, 22], we were unable to analyze variation by race, gender, or socioeconomic status because we did not receive individual-level data on these factors. We also did not have a large enough sample to use school-level demographic data as a proxy for individual-level demographic data [3]. Third, this study did not examine how students react to Mr. Davis' assessments of the accuracy of their causal maps. It is possible that the identification of a mistake may trigger different emotional responses and require different strategies to respond effectively, compared to receiving a suggestion to read a specific page.

Despite these limitations, our study takes a step towards understanding the relationship between help acceptance and help seeking within computer-based learning environments. Our results indicate that help acceptance and help seeking are distinct behaviors in Betty's Brain, and that only help acceptance is significantly related to learning. Consistent with prior research [8], we also found that help acceptance was relatively uncommon: 42% of our sample never followed Mr. Davis' reading suggestions, and even the most compliant student only followed half of the reading suggestions they received. Perhaps counterintuitively, we found that students who accepted help from Mr. Davis made fewer positive statements about him in the interviews. It is possible that this finding points to changes needed in his profile, some of which were addressed in a recent study [13]. Overall, we hope that the results presented here will spur further research to understand the factors associated with accepting and benefitting from system-initiated help.

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