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Full Length Research Paper

The Writing-Pal tutoring system: Development and design

Jianmin Dai, Roxanne B. Raine, Rod Roscoe, Zhiqiang Cai and Danielle S. McNamara*

Institute of Intelligent Systems, Department of Psychology, University of Memphis
38152 Memphis, USA.

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Writing-Pal is an intelligent tutoring system designed to offer high school students writing strategy instruction and guided practice to improve their essay-writing skills. Students are taught to use writing strategies via interactive lessons, games, and essay-writing practice. This paper presents an overview of Writing-Pal's foundations and design, which are based on key pedagogical and educational-technology, and design principles. These considerations are important for the efficacy of the system, as well as its stability and portability in diverse settings, such as the laboratory, classroom, or students' homes. We expect this paper to be of interest to educational developers, as well as other developers who may face similar goals and challenges.

Key words: Writing-pal, writing strategy training, architecture, design, intelligent tutoring system, essay-writing skills, vicarious learning, pedagogy, strategy instruction.

WRITING STRATEGY INSTRUCTION

Effective written communication is an essential skill with critical importance for educational and professional success. Research has indicated that students' writing abilities not only affect their acceptance into college, but are also key predictors of success once enrolled (Geiser and Studley, 2001; Kellogg and Raulerson, 2007; Powell, 2009). The value of writing does not decline after college; professionals in nearly every field report that writing is a significant aspect of gaining employment, day-to-day work, and attaining promotions (Light, 2001; Porter, 1997; Sharp, 2007). Unfortunately, the National Commission on Writing (NCW, 2004; 2008) and National Assessment of Educational Progress (NAEP, 2002) have found that many students tend to be very poor writers. Given the near universal importance of writing, these findings are of grave concern.

The improvement of students' writing via instruction has been a goal of decades of research (e.g., de la Paz, 2007; Graham and Perin, 2007; Hillocks, 1984). One of the major factors that emerge from such reviews is the importance of scaffolded strategy instruction with guided practice. In terms of pedagogical design principles, instructional interventions need to a) teach specific and explicit strategies for planning, drafting, and revising text, b) teach the background knowledge needed to understand and implement those strategies, and c) provide opportunities to practice those strategies over time with ample individualized feedback. For example, de la Paz and Graham (2002) trained adolescents to use a "PLAN and WRITE" strategy. The PLAN strategy helped students plan their essays by attending to the prompt, generating main ideas and supporting ideas, and organizing these ideas. The WRITE strategy helped students to compose their essays by remembering to utilize their plans and goals, and trying to use more varied sentence structure and vocabulary. The strategy instruction took place over a lengthy period (6 weeks) and several stages, including explicit discussions of how and why to use the strategies, teacher-led demonstrations and modeling, and opportunities for supported and independent practice. This training program, typical of strategy-based writing instruction interventions, resulted in student essays that were greater in length, used a more sophisticated and varied vocabulary, and were of higher overall quality. These positive effects persisted over time (that is, after a one month delay).

Although effective, a clear challenge for such strategy instruction is that it requires a tremendous amount of time

*Corresponding author. E-mail: dsmcnamara1@gmail.com. Fax: 901-678-1336.

and effort on the part of teachers - teachers who must already juggle the demands of grading multiple essay drafts from multiple classes, along with other curricular goals such as literacy and literary analysis. Many teachers, especially in the upper grades, may not be able to devote weeks or months to the remediation of "students" poor writing skills. One solution that has been effectively implemented in other learning domains is incorporating intelligent tutoring systems (ITSs) into the curriculum. ITSs programs typically use complex algorithms and/or interactive designs to teach content and strategies in a dynamic and adaptive manners similar to expert human tutors. Indeed, when designed well, these computer systems can support meaningful learning gains comparable to one-on-one human tutoring (Graesser et al., 2005; McNamara et al., 2004; Quintana et al., 2004; VanLehn et al., 2007). Moreover, by providing supplemental instruction inside or outside of the classroom, ITS use can reduce teachers' burden of assisting struggling students (or enriching advanced students) while also adhering to broader curricular constraints. In terms of educational technology design principles, such systems need to be a) accessible to as many students as possible, b) interactive, c) flexible and reconfigurable, and d) able to trace and respond to students' learning processes.

Numerous ITSs have been developed, most often in science (e.g., Graesser et al., 2004; VanLehn et al., 2005) and mathematics (e.g., Aleven and Koedinger, 2002; Beal, et al., 2010). A handful of systems have targeted reading skills (e.g., McNamara et al., 2006). However very few have addressed writing strategies. Summary Street (Wade-Stein and Kintsch, 2004) assists students with writing text summaries. The system initially provides guidelines and examples, and then employs Latent Semantic Analysis (LSA) algorithms to judge whether students' summaries are of sufficient length and relevance. Strategy practice using this software has resulted in significantly improved student summaries. However, Summary Street does not address whole essay composition. Several commercially-available computer technologies focus on giving detailed, extensive feedback on essay quality with automated essay scoring. For example, WPP Online implements the Process Essay Grade (PEG) scoring system developed by Ellis Page (Page and Petersen, 1995; Shermis et al., 2001). WPP Online provides feedback on a variety of dimensions, including sentence structure, word choice, mechanics, and organization. Many skills can be reviewed and practiced in brief animated tutorials. However, the central focus is on essay writing and scoring. The Criterion system developed by the Educational Testing Service (ETS) also offers extensive automated essay scoring (Burstein et al., 2004; Burstein et al., 2003). As with WPP Online, Criterion can rate essays based on usage, grammar, mechanics, and certain elements of style and structure.

The Criterion system does not currently offer any direct strategy instruction, although students do receive ample feedback that contains tips and guidance for future writing. In these kinds of essay scoring systems, students are encouraged to review their feedback and strive to improve their scores. Although such systems may satisfy the pedagogical principle of practice and feedback, they often do not adequately address principle of scaffolded strategy instruction. As such, they may neglect one of the critical elements that are known to effectively improve students' writing skills. In contrast, such instruction is the central aim of Writing-Pal (W-Pal), an intelligent tutor for writing strategies. W-Pal teaches specific strategies used by competent writers. It then encourages students to practice increasingly difficult essay-writing tasks that incorporate these strategies. Essay scoring algorithms are used to provide the feedback students need to gauge and improve their performance.

WRITING-PAL FRAMEWORK AND PRINCIPLES

W-Pal provides scaffolded strategy instruction via a series of Writing Strategy Modules corresponding to three broad phases of the writing process: prewriting, drafting, and revising. The prewriting modules (Freewriting and Planning) teach strategies to help students access their prior knowledge, generate potential arguments and evidence, and organize these elements into a structured essay plan. The drafting modules (Introduction Building, Body Building, and Conclusion Building) cover strategies for providing a clear and engaging start to an essay, developing one's arguments in several body paragraphs, and then finishing with a strong conclusion that ties the essay together. Finally, the revising modules (Paraphrasing, Cohesion Building, and overall Revising) are designed to assist students with finding better and more diverse ways to clearly and coherently express themselves and carefully review their work to make sure it meets the requirements of a thorough essay. Each module comprises an instructional Lesson and several practice Challenges. More detail about the content and rationale of individual modules is provided elsewhere (McNamara et al., in press), but a brief overview is provided here with an example of one of the modules.

Each lesson is developed using a similar overall narrative and context: lessons take place in a virtual classroom in which a "teacher" agent named Dr. Julie discusses writing strategies with two "student" agents, Sheila and Mike. Each agent is a computer-simulated character with a distinct appearance, voice, and personality. Thus, rather than purely didactic tutorials in which information is merely delivered to students, each module is a highly interactive dialog between the three agents. Research on vicarious learning with animated pedagogical agents (Craig et al., 2004; Johnson et al., 2000) has shown that this can be a powerful means of

making content and strategy instruction available to students. For example, the iSTART system, which effectively improves students' reading comprehension via self-explanation strategies, relies on a similar arrangement of agents and vicarious learning (McNamara et al., 2004). Within each lesson, students are provided background knowledge about the target essay goal and specific strategies for achieving those goals. Often, these strategies and requirements are summarized by a mnemonic device that serves as a checklist students can use to guide their writing process. Many examples are provided throughout the lesson. Also included within each lesson are a series of quiz-like or game-like "checkpoints." Some checkpoints ask multiple-choice questions to probe recall of recently covered information. Others ask students to apply the strategies or generate small samples of text. Pedagogically, these checkpoints help to focus and maintain students' attention on key concepts, while providing immediate opportunities for practice with feedback. They also serve as assessment points to identify how well students are progressing through the lesson.

Strategy instruction and practice are not limited to the lessons and checkpoints. Each strategy lesson is complimented by numerous challenges. These challenges are game-like opportunities for extended practice with feedback from the system. Others have proposed that the important factors influencing the success of edutainment environments are storytelling, challenge, interactivity, and interface (Embi, 2005). To address these needs, each of our challenges contain a narrative and/or immersive challenge, scaffolded difficulty, feedback, and are designed within the same interface framework. More specifically, we expect that our challenges meet the edutainment requirements set forth by Embi (2005) in their possession of these features. The narrative or immersive aspects of the challenges are achieved through maintaining underlying themes within each activity, many of which recur throughout numerous activities and across lessons. Underlying themes provide an underlying storyline to provoke student interest. The inclusion of scaffolded difficulty within each challenge serves to prod students in a way that should build off of the knowledge students should have obtained by viewing each challenge's corresponding lesson. Interactivity is enhanced by personalized artificial intelligence and feedback. This feedback is provided in the form of direct and immediate responses to the students' particular answers to questions, and should aid in further scaffolding their knowledge as well as increase the interactivity of the system. Finally, the inclusion of these challenges within the familiar W-Pal interface is expected to provide ease of use and control for students with regard to navigating and understanding the game design. Embi's (2005) requirements and W-Pal's strategy for addressing these requirements are explained below in further detail.

Underlying themes

Some challenges ask students to identify and classify examples (e.g., identify an appropriate thesis statement) whereas others ask students to manipulate information (e.g., sort argument and evidence sentences into an outline) or generate text (e.g., write a conclusion paragraph for an essay). Although each challenge includes a storyline, the challenges are diversified enough to differ in the extent to which they are puzzle-like or narrative. One narrative game is "Speech Writer," in which students are placed in the role of a speech editor for a politician. Depending on their proficiency in the task, they may hear the crowd cheer at the end of their speech, or they may hear cricket noises if they have performed poorly. A more puzzle-based game is "Ready, Sets, Go," which is a card game that resembles Gin Rummy, wherein students match strategies with their associated lessons.

Scaffolding and games

Each challenge game builds off of the knowledge students are expected to have obtained within the challenges' corresponding lessons. Thus, they are a slight degree more difficult than the checkpoint quizzes and activities within the lessons themselves. Furthermore, many of the challenge games have more than one version. As such, students who have mastered the easier versions of these challenges can move on to more difficult challenges. For example, in the first version of "Ready, Sets, Go" that is described above, students get a "hand" of cards that have strategies and their associated lessons written on the cards. They are to match these strategy/lesson cards with lesson cards that appear at the top of their screens. In the more difficult version of this game, many of the cards in the students' hand do not have the lesson printed on them. Rather, they have the strategy listed without the lesson and must match the strategy card to its corresponding lesson relying on their recollection of content presented within the W-Pal system. In this way, the first game allows the student to become familiarized with the task and to receive further exposure to the content, whereas the second, more difficult version of the game, tests this associative knowledge between strategies and lessons.

Interactivity and feedback

In many of the W-Pal challenges, feedback on students' responses is generated based on Natural Language Processing (NLP) algorithms. Students practice strategies and skills taught in the lessons as they play the challenges. By making strategy practice game-like, we hope to maintain greater student engagement, and thus

Figure 1. From this page, students can easily navigate from one section of Writing-Pal to another.

increase the amount of time that students choose to practice (Gee, 2003; 2008). In this way, we address two important aspects of educational games: pedagogy and game design components (Tan et al., 2007).

Interface and design

The interface of W-Pal (shown in Figure 1) is self-contained, intended to be used over a long period of time (6 months to one year and beyond), supplemented by tutorial videos (The student tutorial video is available on YouTube: http://youtu.be/bKovhZ-6mNY) for "teachers" or students, sufficiently consistent across tasks, easily accessed locally or remotely on any browser or operating system, and quick to load with minimal storage and processing demands. The details behind these requirements and how they are met are explained in the fourth section of this paper, wherein we discuss the design of our system.

WRITING-PAL STRATEGY LESSONS AND TRAINING

To provide a more concrete example of W-Pal's instructional content, consider the Writing Strategy Module for learning how to begin an essay, "Introduction Building." The Introduction Building lesson begins with a discussion among the agents about the importance of beginning an essay well and the rhetorical goals that a good introduction must satisfy. This is summarized using the "TAG" mnemonic and checklist: (T)hesis statement, (A)rgument preview, and (G)rab the reader's attention. Students are then taught how to write a thesis statement that clearly states the author's position and connects to the main supporting arguments. Next, students are taught to preview their arguments in more detail, making clear to the reader what the essay will be about without explaining the evidence yet. Finally, students are presented with several techniques they can use to try to engage the reader's interest, such as sharing a personal anecdote, asking leading questions, or using an illustrative historical example. Interspersed with these strategies are several checkpoints in which students are asked to judge or identify examples. A simple quiz-like checkpoint is shown in Figure 2. Another set of checkpoints within the Introduction Building module is framed as a game, "Mission to the Moon." In this game, students collect moon rock samples by correctly identifying the attention-grabbing technique used in a paragraph. Students receive points for each correct answer and a final score at the end.

The Introduction Building lesson discusses the requirements of introductory paragraphs along with strategies for fulfilling those requirements. Although there are opportunities to practice within the lesson, the majority of the practice is situated within several game-like challenges. New games are continuously being developed, but here we will highlight two cases. The first challenge, "Essay Launcher," (Figure 3) revisits the "Mission to the Moon" checkpoint narrative, except that now the player is returning their spaceships home to

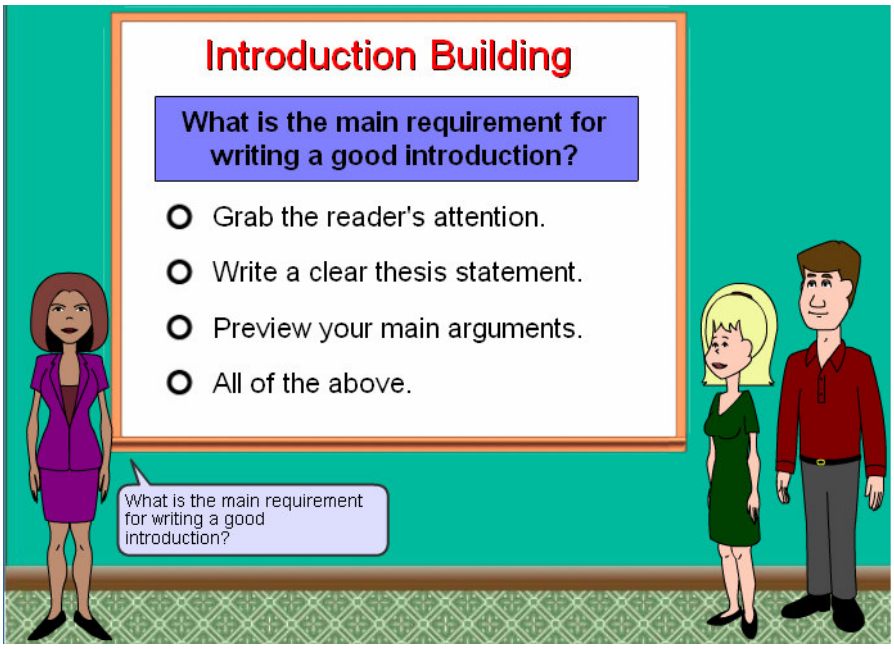

Figure 2. The Introduction Building lesson includes checkpoints that are intended to keep the students' attention during the lessons.

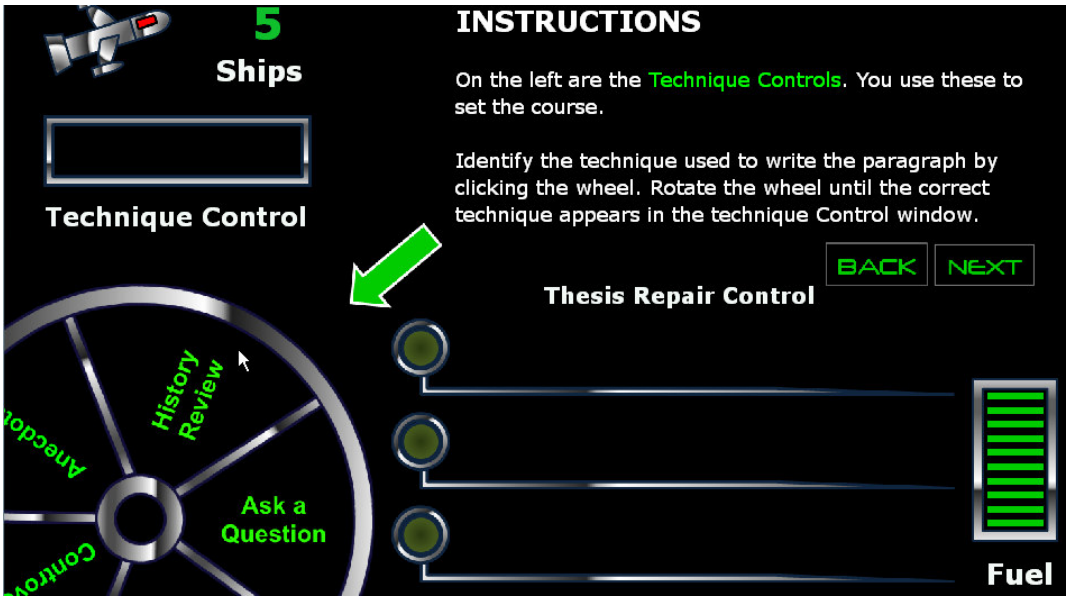

Figure 3. In the Essay Launcher challenge associated with the Introduction Building lesson, students are required to identify the technique used in a given introductory paragraph and chose the best thesis sentence for the given paragraph.

Earth. To successfully pilot five ships home, students must perform two tasks: 1) identify the attention-grabbing technique used to write the paragraph (from a list of five techniques), and 2) choose a thesis statement that would be most appropriate for that paragraph (from a list of three options). In this challenge, students are exposed to many introduction examples and asked to think critically about their defining features. For example, what cues or information indicates that a historical example is being used? What kinds of language are used when the Set a Scene technique is employed? What is the basic structure of a higher quality, relevant thesis statement?

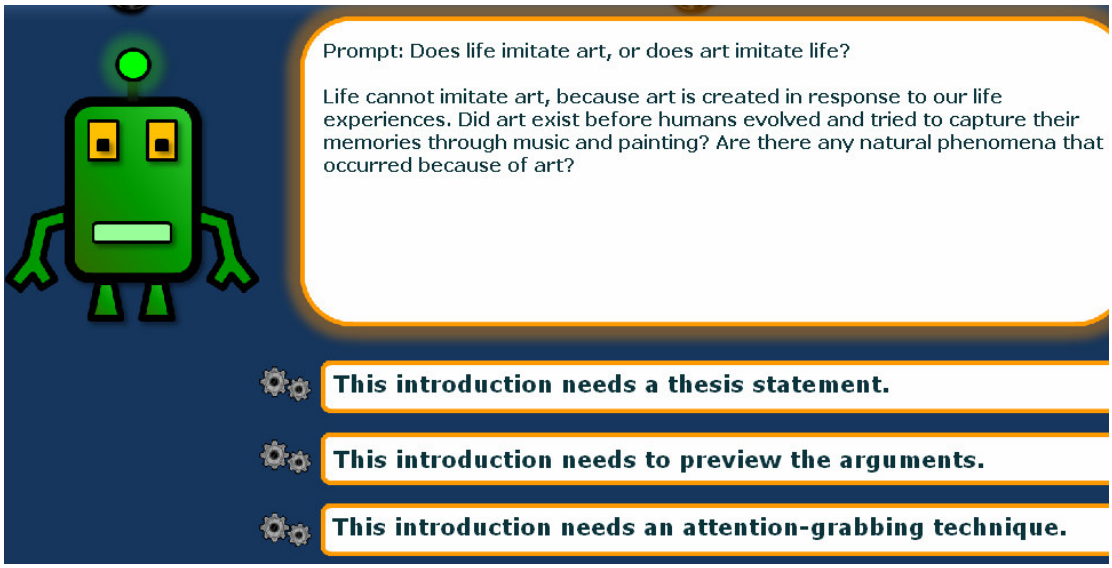

Figure 4. In the challenge Fix It, students must identify problems with introductory paragraphs.

A second challenge, called "Fix It," (Figure 4) does not possess a story-like narrative, but is instead more like a game-show. In the "Regular Round," students are presented with an example introduction and asked to identify what is wrong with the paragraph, if anything. That is, does the paragraph lack a thesis statement, an argument preview, an attention-grabber, or is the paragraph complete? This evaluation task helps students practice using the TAG mnemonic to evaluate the completeness of an introduction, which is a skill they must learn to apply to their own writing. Students earn points for making correct answers with few mistakes and are given feedback on right or wrong answers. After identifying a problem in the Regular Round, students enter a "Bonus Round" in which they are asked to choose (from a list of two options) a piece of text that will fix the paragraph. If a thesis statement was missing, students must choose an appropriate thesis, and so on. After completing six Regular Rounds, students who have achieved a high score are rewarded with access to a "Super Bonus Round." In this round, students are shown a flawed introduction, told what the flaw is, and then must generate the missing text. For example, if the paragraph lacks an argument preview, the students will need to fix the paragraph by generating plausible arguments. NLP algorithms determine whether students' generated text is adequate (see McNamara et al., in press). Via this challenge, students' skills in both self-evaluation and generation of essay introductions are practiced and reinforced.

It is important to note that writing strategies are not practiced only componentially via targeted challenges such as Essay Launcher and Fix It. Students also practice writing full essays using the Essay Writing tools. At any time or when assigned an essay by a teacher, students can write an essay on one of many pre-set prompts and receive feedback (generated via NLP) on various aspects of their writing. Writing feedback first focuses on basic concerns such as length, relevance, and paragraph structure. Students are asked to revise to improve their essays. Once basic elements are in place, essays receive holistic scores along with feedback targeting the weakest areas. For example, if a student writes a "Good" essay (rating of 4 out of 6), they will be reminded of specific revising strategies and given additional feedback on two areas that could benefit from focused revision (that is, introductions, body paragraphs, conclusions, or mechanics). This process is iterative. For assigned essays, students may revise as many times as allowed by their instructor. For purely practice essays, students may revise as many times as they wish.

Overall, the content and design of the Strategy Module Lessons follow the pedagogical design principles outlined above. By participating in the full series of eight modules, students are taught a variety of explicit strategies for all three phases of the writing process - prewriting, drafting, and revising. Each lesson provides students with the background knowledge needed to enact the strategies, as well as opportunities for immediate practice and feedback. Further strategy practice is offered in the form of engaging games that allow students to practice every strategy, with automated feedback, whenever the students desire. Finally, the essay writing interface and feedback allows students to combine and integrate these skills in the process of composing complete essays. While writing and revising, students can freely return to the various lessons and challenges for review and practice. In fact, students are often encouraged to do so in the feedback they receive. As mentioned above, these lessons and training components are presented in a user-

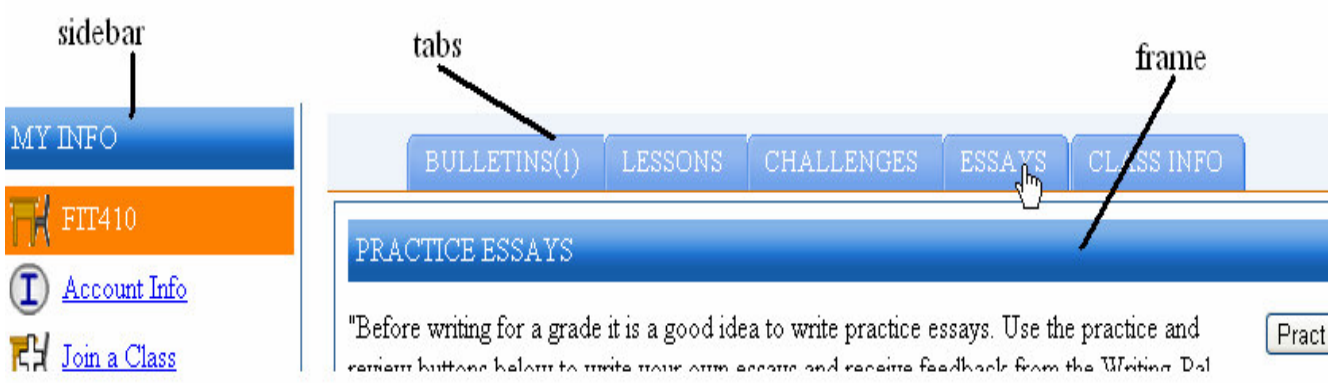

Figure 5. The W-Pal interface's navigability is enhanced by the use of frames and a consistent sidebar. The current activity appears in a frame (the Practice Essay activity is pictured above), whereas the tabs above the frame and the sidebar remain constant while the user is in W-Pal. Some other activities appear in a pop-up window with the W-Pal interface in the background behind the window.

friendly way with an all-inclusive desktop workspace, which is intended to facilitate the student's ease of use with the system. W-Pal is designed to achieve the interface needs of an educational system. The details behind W-Pal's design and how it accommodates ease-of-use within its interface are described below.

WRITING-PAL DESIGN

W-Pal's is designed to provide a powerful learning environment that has an easy-to-master navigational logic. By streamlining the users' interactions with the system, the teachers can dedicate their time and efforts to more important tasks (e.g., actual teaching), and the students can spend more time learning about essay-writing (as opposed to learning how to use the computer program itself). However, this is not the only consideration that should be fundamental to an ITS's design. Other features needed in an optimized educational environment include accessibility, relative consistency, pedagogically motivated and accurate feedback methods and algorithms, and flexible configurability. Our solutions to these obstacles to comprise of a number of design features that, although certainly not novel, we expect to be of interest and useful to other designers, whether they be pedagogically-oriented or pleasure-based gaming interface designers. Below, we discuss each of these features in turn: navigability and consistency, accessibility, feedback accuracy, and flexible configurability.

Navigability and consistency

Navigability refers to the ease with which one can retrieve useful and desired information from a system. Tried and true measures of navigation success include time spent getting from one's current state to a desired goal location, self-reported ease of use, amount of support needed to learn the aspects of a system, and the degree to which features within a system are used or visited (e.g., Palmer, 2002; Pitkow and Kehoe, 1996). Consistency, on the other hand, regards the system's overall coherence and presentation style (Nielson, 1993). For example, in a consistent multiple-paged interface, the user will know where to look for links to desired pages by virtue of having previously visited other pages with similar presentation styles. That is, if a system has sufficient consistency, users should have greater ease in navigating the system because components are presented similarly throughout the interface for the entire system. Thus, although navigability and consistency are entirely different aspects of a virtual environment, it is appropriate to discuss them in tandem as consistency can contribute so greatly to the system's navigability.

Consistency within W-Pal is achieved in a number of ways. First, the overarching frame of W-Pal is constant throughout one's W-Pal experience. The outer frame of the system is comprised of a tabulated button list at the top of the screen, situated over an embedded window and a sidebar containing various other links. This frame-like structure allows the user to navigate through many aspects of the system without the framing area changing at all. The window within the frame is where pages such as class bulletins, lesson lists, game choices, and scoreboards can appear. Thus, many aspects of the W-Pal system are accessed through a window that is embedded within the main W-Pal frame. A sidebar also remains constant, which provides links to other classes in which the user might be enrolled, links to printable PDF handouts for students (or answer keys to these handouts for teachers), and other such supplementary system tools (Figure 5).

However, there are aspects of W-Pal that are best experienced when not embedded within the overarching

W-Pal frame. Namely, the lessons, challenges, and essay-writing practice components and tests are more immersive if they appear in their own windows as opposed to the alternative option of presenting them embedded within the frame, which might be distracting to users who are engaging in an interactive task. As such, these activities appear in a pop-up window. This solution optimizes the consistency of the system without compromising its immersive potential. While students have a pop-up window open, they are prevented from engaging in other tasks. However, they are free to close the current pop-up window at any time. If they close a lesson video before completing it, they can return to their desired spot in the lesson videos up to their level of progress in that particular lesson. For example, if a student were interrupted after watching 75% of the Introduction Building lesson, the student would return to that 75% marker when the lesson was resumed. Furthermore, the student could then return to any point in that lesson from 0 to 75% (any point up to the point at which the video had been watched). After viewing a lesson in its entirety, students are able to access any point in the lesson at any time in the future. This feature of resuming where one left off and unlocking as one progresses is achieved by an XML-Binding mechanism that bridges the modules and their components. The lesson record is updated to the server every 5 seconds, which provides accuracy in assessing the student's real-time progress within the ITS.

This use of framing and pop-up windows does not only serve to strengthen the system's configurability and navigability. Rather, the combination of an outer frame, an embedded window and supplementary pop-up windows also contribute to W-Pal's overall usability. As Shneiderman (1998) points out, user interfaces should be well organized (Fang and Holsapple, 2007). These features, along with a clear presentation, help ease cognitive load demands on users. Other aspects of the W-Pal experience should also aid the users with finding their way around. Namely, the system's consistency is enhanced by the long-term usage with which its clients will be exposed. That is, once they have learned the links within its constant external shell, they will be repeatedly exposed to this exact same frame each and every time they use any part of the W-Pal program. In any case, all users are provided with a quick and clear tutorial video in their first exposure to the system. These aspects of configurability and hence navigability are expected to contribute to the user's experience in W-Pal based on prior research showing that configurability and navigability are substantial factors influencing usability (Palmer, 2002).

Accessibility

W-Pal's accessibility arises from its ease of use across platforms, as well as its functionality in environments with internet connectivity limitations. There is an online version that can be deployed to a web server, as well as a downloadable version that is compatible with Mac or Windows operating systems. An important consideration in the development of systems that are intended for use in classrooms is the availability of (or lack of) a network connection. The W-Pal system is designed to run smoothly with or without a network connection. All actions relying on network connections can be recorded into a network log in the case that a network connection is not available. The network data service layer has been designed to provide the connection managing, XML-RPC and real-time message services. This Connection Managing Service monitors the network connecting state. This prevents network disconnections from hindering the students' learning processes. Because user interactions depend on the network connection, the connection managing service ensures that all interaction data is saved to a local database.

Additionally, a Database Service Component provides the JDBC-driven SQL interface for the students to store or query the learning data (including record of their progress and achievements) from MySQL database on the server. For example, a Freewriting Feud game, the final score needs to be stored to the database after finishing the game, and the day's top 5 leaders are displayed via a database query. Local data is uploaded to a centralized server through calling Database Service when the network is connected. An auto-restore mechanism is incorporated in the system so students can continue from their previous break point by retrieving the current state from the data server.

Feedback accuracy

W-Pal achieves its capacity to provide immediate and personalized feedback via NLP tools, such as a lemmatizer, syntax parser, WordNet utility, and Latent Semantic Analysis, among others (McNamara et al., in press). Although NLP is computationally costly, it is necessary for providing the level of analysis and precision of feedback that W-Pal aims to achieve. Certainly, as shown above, others have found systems similar to this one are quite effective in other domains (e.g., Litman and Silliman, 2004). In Freewriting Feud, students are asked to freewrite on a topic. Based on our experiments with freewrites, we have determined a number of words that appear frequently in freewrites that human raters scored high, but do not appear in freewrites that received low scores from human raters. As such, once the student has freewritten on a topic, we can assume that their freewrite would be scored highly by human raters if they used the words that are unique to highly scored freewrites. Thus, in the Freewrite Feud game, the appearances of six keywords in the user's

freewrite are the basis for their success in the Freewrite Feud challenge. Once the student has completed a freewrite, these key words flip one-by-one in 1-second intervals.

W-Pal has required an extensive amount of corpora collection in order to develop lessons and practice modules. For example, the corpus of introductions is a collection of essay introductions used in the Dungeon Escape game. For each lesson, corpora must be collected to determine correlations between essay features and human-rated quality. To date, we have collected nearly 1,000 essays which have been scored by expert human raters. Additionally, these human ratings have been correlated with our Coh-Metrix features (see McNamara et al., in press) to determine automated algorithms for providing feedback on individuals' essay and freewrite inputs to the system. Aside from the value added to our system in terms of correlations between computational assessments of essay features and human ratings, our corpora of sample essays also inform our system design in a number of ways. For example, the freewriting corpus provides a collection of writing assignments, prompts, and examples of good and poor freewriting texts. Based on our studies with human subjects, we have determined effective freewriting instructions that depend on the user's preexisting essay-writing skill level. Higher skilled writers do not benefit from the same kind of practice as lesser skilled writers. This corpus has also helped us to determine differences in freewrite content between higher and lower skilled writers. With this knowledge, we can make more educated decisions about how to structure our practice exercises and challenges as we continue to improve our system.

NLP algorithms play a critical role in W-Pal, both during the mini- and full practice lessons as well as during the final phase of writing complete essays (see McNamara et al., in press). Supplying adequate and online feedback to the students about their writing is one of the most challenging aspects and most important features of the system. Algorithms are needed to assess students' input during practice as well as their writing quality and the strategies they have used when writing full essays. These NLP tools include a lemmatizer, part-of-speech tagger, syntactic parser, Latent Semantic Analysis, and WordNet. These tools are deployed on the high-speed server. Each module in W-Pal can access these tools using a client-server socket connection.

Configurability

W-Pal is highly configurable in two regards. First, it is highly configurable from a designer's perspective, allowing for quick modification to the system throughout its development and deployment. Second, it also provides its teachers with a great deal of power in personalizing their courses on a global level (that is, all of their classes) as well as a local level (that is, for particular classes). The W-Pal lessons are constructed with Media Semantics' Character Builder software (www.mediasemantics.com), enhanced by Loquendo text-to-speech engine technology (www.loquendo.com). The Loquendo text-to-speech technology gives a substantial amount of control over the agents, such as playing, pausing, resuming, and stopping the agent dialogue, as well as dispatching the event to callback when completing one of the XML-formatted scripts. This design allows for ease in changing dialogue speech scripts as well as control over the flow at each speaking end-point. To achieve these implementations, W-Pal currently relies on Character Builder software to produce flash files of the lessons and feedback dialogue speeches.

W-Pal includes numerous basic components that are presented via the flash lesson player, including the agents' dialogue, the interface and avatar animations, a variety of games' background music, and various other sound effects. In order to incorporate such a diverse collection of features in the W-Pal user interface, a common library is required. This library is comprised of components for converting, loading and playing multimedia, parsing corpora, designing animations, and designing the dialogue system. Because the common library is independent from many of the interactive activities, they can easily be replaced and modified. Another advantage of the use of this common library throughout the system relates to the system's accessibility. By drawing from a common library, many sound events in the games and other components of the ITS can occur by issuing a call back action to a single file. Each time an event happens that should invoke that sound effect (or video, image, etc.), only one audio file needs to be stored and accessed. The reuse of sound effects within the common library reduces memory requirements for those running the system locally by downloading it on their computers and it also minimizes load time for those accessing the system online. An additional component of the ITS stores the lessons. More specifically, the Strategy Lesson Training Index XML file stores the strategy lessons. A training index xml file is used to store the strategy lessons in order to easily add, delete, or update the strategy lesson without having to make revisions to the program codes. All corpora are described in XML format. Therefore an XML Corpus Parser has been built to easily reuse these corpora for different purposes.

Aside from W-Pal's configurability capabilities for the designer and future designers who might modify the system, it is also highly configurable for each individual teacher as well. For example, teachers may create their own essay-writing assignments or tests, choose to have these essays timed or untimed, proof-readable or required to be completed by the students in one sitting,

and other such specifications. The teachers may also choose to provide a particular assignment to all of their classes or to individual classes. Due dates can easily be assigned within the system as well. Teachers can add other instructors, delete and add students to their databases, evaluate and modify scores on essay assignments, track students' progress throughout the system on an individual basis or for the class as a whole, create assignments, adjust W-Pal grades, make bulletins, and designate tasks as priorities that must be completed before students are allowed to navigate to any other part of the system.

DISCUSSION

W-Pal has been in the development process for over a year. Although it is not the only writing tutorial program, it is indeed different from those currently available, commercially or otherwise. W-Pal includes strategy instruction that is soundly based in empirical studies found throughout ITS disciplines, as well as pedagogically effective components such as scaffolded training, game-based learning, and feedback-enhanced practice. W-Pal includes feedback on a number of levels and provides a number of different types of learning experiences for students. In addition, it incorporates a number of important design principles that have been shown to substantially increase usability and overall user experience. The underlying themes give it conceptual consistency, whereas the games are scaffolded to provide enough variation with the game play without overwhelming the students. NLP and empirical studies inform the feedback mechanisms, which provide personalized interactivity.

Furthermore, the interface and design of the system are informed by numerous usability studies (many of which are still in progress), that aim for navigability and consistency to make the system easier to manage, reduce cognitive load on the users, and allow more time to be allocated towards writing tasks. The system is highly accessible, with multi-platform compatibility and on- or off-line capabilities. W-Pal's architecture renders it easy to define system requirements with writing strategy XML schema, and easily expandable. It also minimizes processing needs with the capacity to reuse the common components. It is also highly configurable for designers as well as instructors.

There are certainly a number of ways to implement and incorporate all of these features within a system. The methodology used in designing W-Pal is not necessarily novel in that the approaches chosen in creating this system have each been used in other contexts. However, to our knowledge, the incorporation of all of these features within one system has not been done before in this way and for this purpose. As such, this paper should be valuable to other designers and engineers who face similar challenges.

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