Reflection in professional play

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Introduction

Computer simulations make it possible to create *computational microworlds*—"environments where people can explore and learn from what they receive back from the computer in return for their exploration" (Hoyles, Noss, & Adamson, 2002). This has been shown in STEM programming environments (Papert, 1980; Resnick, 1994; diSessa, 2000), direct manipulation environments (Goldenberg, and Cuoco, 1998), and game worlds (Adams, 1998; Barab et al., 2001). Working in these environments gives students opportunities to learn STEM subjects through problems that are realistic, complex, and meaningful.

At the same time, simply turning students loose in a computational microworld—no matter how cleverly designed—is a poor instructional strategy (Kirschner, Sweller, & Clark, 2006). Putting students into a complex environment and asking them to figure out the underlying rules does not work because "learners are novices [and] leaving them to float in rich experiences with no support triggers the very real human penchant for finding creative but spurious patterns and generalizations" (Shaffer et al., 2005).

A key component in turning activity in a STEM microworld into STEM understanding in the real world is *reflection*: a student's ability to step back from a task and talk with peers and mentors about what worked, what didn't work, and why. Studies of expertise, particularly in STEM domains, show that this *combination* of action and reflection develops sophisticated ways of thinking (Schon, 1987; Shaffer, 2004; Shaffer, 2005; Shaffer, 2007; Bruner, 1996; Dreyfus & Dreyfus, 1986). Authentic training practices in STEM fields can thus provide a model for integrating action and reflection for STEM understanding.

Epistemic Games

In epistemic games, players develop STEM expertise by playing as novices training to be STEM experts of a particular kind: engineers, urban planners, science journalists, and so on (Beckett & Shaffer, 2005; Hatfield & Shaffer, 2006; Shaffer, 2004; Shaffer, 2005; Shaffer, 2007). Because expert mentoring is part of any professional training, explicit guidance is part of any epistemic game. But it is the kind of mentoring that STEM professionals get in their practicum experiences, rather than the traditional direct instruction of school-based learning or the skill-and-drill in basic facts and skills that too many educational games currently provide.

In the epistemic game *Urban Science*, for example, players become urban planners to redesign their city. They use a geographic information system (GIS) model to propose land use changes (for example, turning a parking lot into a neighborhood park and playground) to improve quality of life. In the game they perform the kind of *actions* that urban planners do in their training: They receive materials that urban planners use, such as a city budget plan, that provide information about revenue, pollution, and other issues. They conduct a site visit and interview virtual stakeholders. They use a GIS model to create preference surveys and construct proposals for redevelopment.

But in *Urban Science*, people playing the role of planning consultants—*game mentors* (GMs)—also engage players in the kind of reflection that planners use to turn planning activity into understanding of the planning process and the STEM concepts relevant to the planning profession. During individual work, team meetings, and interactions with clients and supervisors, GMs ask players to answer questions like: *What's the problem? What have you tried? What other options did you consider? How and why did you decide which options to take? What worked well and what didn't? Why?* Research on *Urban Science* shows that asking these questions as part of the illusion of a simulated work environment is a powerful educational tool (Beckett & Shaffer, 2005; Shaffer, 2007).

Professional Practice Simulator

In our current work, we are developing and testing a *professional practice simulator* (2PS) based on our studies of *Urban Science*. The 2PS is a game engine designed to integrate action in the game and reflection on that action within the game technology itself, based on the way that reflection and action are integrated in professional training.

To provide this technological support for reflection and action in the game, the 2PS is designed as a shared workspace that simulates the technologies and workflow of a professional office. The overall interface is a virtual planning company's intranet or portal, which provides various services to planning team members, aka players.

For example, players interact through simulated email with virtual supervisors (non-player characters or NPCs) and peers. Reading and/or replying to messages triggers dynamically generated NPC responses. Throughout the game players are prompted by NPCs to email work products and accompanying justifications or explications. The 2PS can then generate NPC feedback using thin AI models of the NPCs operating on pre-defined features of the emailed products. For example, the 2PS system can check that a proposed GIS model meets minimum criteria outlined by a client and produce an email response from an NPC from a database of pre-defined responses for that criterion. As a result, the 2PS can harvest reflections embedded within messages and attachments, and the email interface thus controls the overall activity flow while simulating feedback from coworkers, stakeholders, and clients to drive players' reflections.

Goals

The goal is not to have the 2PS simulate all forms of reflection in the game virtually. It is instead to provide technological scaffolds for explication and justification within the game by (a) tracking players' progress through the game and asking appropriate reflective questions at appropriate times, and (b) providing realistic feedback to proposed plans modeled in the professional tools integrated into the system. We recognize that game mentors play an important role in helping players reflect on their actions with professional tools in the virtual world of the game. The goal of the 2PS is to create in silico elements of game mentoring that are both feasible and appropriate given the learning processes of the professional practicum, and thus to make the illusion of the game world more realistic while lowering barriers to game play by simplifying the role of the adults in the game.

Based on our prior work on *Urban Science* and other epistemic games, we hypothesize that offloading elements of reflection in this way will (a) reduce the amount of training, effort, and number of adults required for game play; and (b) increase players' immersion in the simulated work environment by providing multiple sources of feedback in addition to the GMs. If these hypotheses are correct, it will be possible to reduce the barriers to using epistemic games for STEM learning. More generally, understanding how to offload elements of reflection from social to technological resources will make it possible to improve the efficacy of games for STEM learning more generally.

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“They listen to stakeholders”: Promoting civic thinking through epistemic game play

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Introduction

Democracies today face ecological crises such as global climate change, water scarcity, and widespread disease; issues which cannot be solved with basic facts and basic skills alone. These crises are simultaneously crises of knowledge and skills, but also crises of values. As such, we need to develop a mode of education that is simultaneously ecological and civic and is based on the knowledge, skills, and values that guide actions.

Ehrlich (2000) argues that education should foster and maintain democracy by proposing a more specific model for educating and involving youth in civic issues. For Ehrlich, civic thinking is composed of three separate, but interrelated elements: 1) *knowledge*, 2) *skills*, and 3) *values*, or as he describes it, “mutually interdependent sets of knowledge, virtues, and skills” (xxvi). Here, we use Ehrlich’s conception of civic education to examine how a particular kind of computer game, an epistemic game, modeled on a professional urban planning practicum can promote civic thinking in young people.

Theoretical Framework

Shaffer (2006) argues that becoming a professional, such as an urban planner, involves developing the epistemic frame—the ways of knowing, of deciding what is worth knowing, and of adding to the collective body of knowledge and understanding—of a particular community of practice. For example, professional urban planners’ epistemic frame involves thinking about cities as systems, using their skills to enact planning processes, and valuing serving the public interest.

Epistemic games are role playing games that give young people the opportunity to learn the knowledge, skills, and values of a profession by simulating professional training. For example, in the game Madison 2200 modeled on the professional practices of urban planners, players developed knowledge of systems thinking and core skills important to the planning practice. In other words, by playing a well-designed game based on the training of real urban planners—rather than on a fictionalized process of urban growth and development like SimCity—Madison 2200 provided players with an urban planning framework—the knowledge and skills—for engaging in a course of action that paralleled the decision-making processes and technological tools of practicing urban planners. (Beckett and Shaffer, 2005) Here, we extend that work through the epistemic game Urban Science by looking not only at knowledge and skills, but at the acquisition of values.

Methods

Urban Science was designed based on an ethnographic study of an urban planning practicum. Similar to the practicum, Urban Science players were charged with redesigning three neighborhoods. They researched the history of the sites, conducted physical site visits to see first-hand the character of the place and virtual site visits where they met with virtual stakeholders expressing their concerns about the neighborhoods. Players then used iPlan, a custom-designed Geographic Information Systems tool to create preference surveys to submit to stakeholders for feedback. Using the stakeholders’ feedback, players completed final plans and compiled final reports before presenting to professional planners and city officials who provided players with input and feedback on their plans.

In the summer of 2007, twelve middle school students (4 girls, 8 boys) played Urban Science during a four-week summer program. Clinical pre-, post-, and follow-up interviews with the players were transcribed and broken into excerpts. Paired t-tests were used to compare interview responses between pre, post, and follow-up interviews in matched-pair questions.

Excerpts were coded for knowledge of systems thinking when players used specific vocabulary or terms of art from the domain or urban planning and mentioned interactions inherent in cities: “[W]ithout it you wouldn't really know what the consequences were of the decisions the city makes—like by putting high-density housing might increase the crime in the area, or greenspace and trash.”

Coding for skills occurred when players referred to professional planning practices: “[Planners] listen to stakeholders, they also do background research and site visits...Because they need to know the kind of neighborhood, the history of it, what is it like, what are the people that live there like.”

Coding for values occurred when players referred to particular norms of good urban planning practice: "…The main goal is…trying to come up with a solution for all the different opinions and point of views."

Results

Players talked about aspects of systems thinking such as interconnectedness significantly more after the game than before the game (pre = 0, post = 8, follow-up = 9; $p<0.05$).

Players discussed using planning skills significantly more during the post-interviews than during the pre-interviews (pre = 5, post = 11, follow-up = 10; $p<0.05$).

Players mentioned serving the public interest significantly more during the post-interviews than during the pre-interviews (pre = 2, post = 9, follow-up = 7; $p<0.05$).

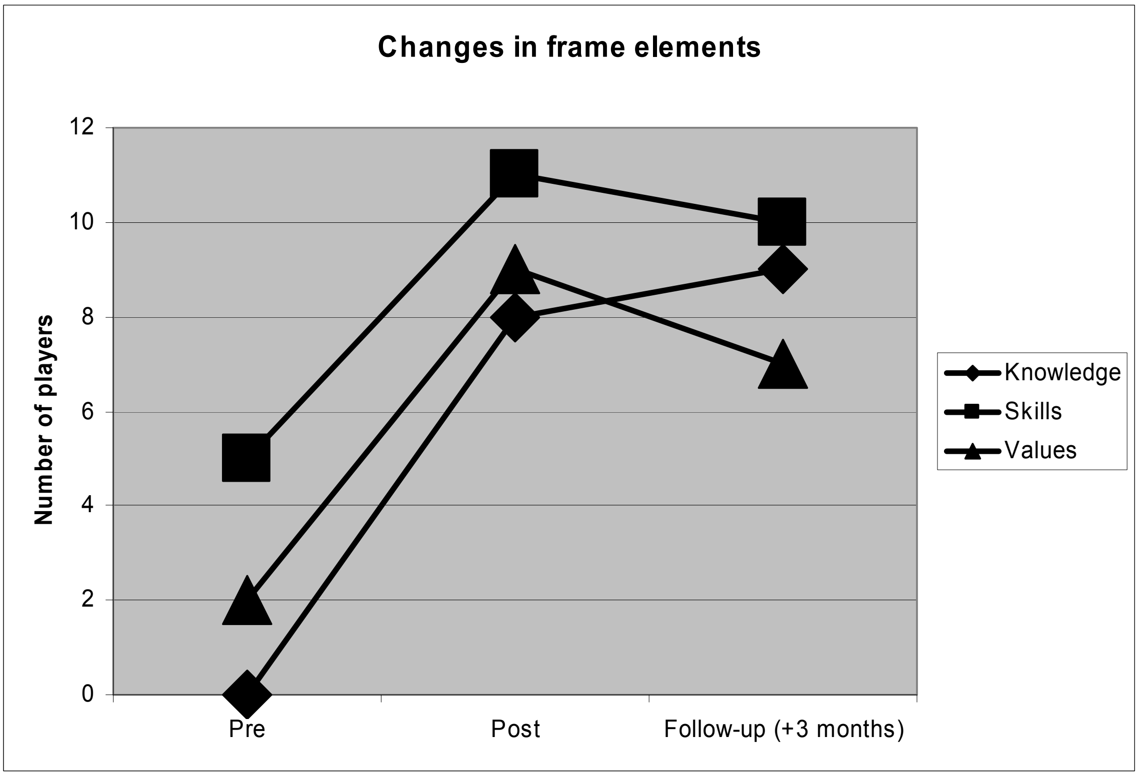

Figure 1: Changes in frame elements for twelve Urban Science players

In short, through playing Urban Science, players learned about systems thinking, enacting planning processes, and the core planning value of serving the public interest.

Discussion

By participating in authentic professional practices like managing physical and social tradeoffs and negotiating compromises between stakeholders, players in Urban Science gained knowledge, skills, and values important to the planning profession and used those traits to better understand the complexity of the urban system. Further, through playing Urban Science, players learned the type of civic thinking urban planners employ—the type of thinking that enables them to see their local contexts as dynamic spaces that they can help mold and shape and consequently, envision a particular role for themselves in their community.

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Digital Zoo: The effects of mentoring on young engineers

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Introduction

Contemporary video games are profoundly engaging and motivating to young people. They keep the gamer focused for hours at a time. (Gee, 2003) But students need more than time, engagement, and motivation to develop deep understanding through game play.

More than 3 decades of research have shown that computer simulations make it possible to create computational microworlds—"environments where people can explore and learn from what they receive back from the computer in return for their exploration."(Hoyles, Noss and Adamson, 2002) Working in these environments gives students an opportunity to learn by tackling problems that are realistic, complex, meaningful, and motivating. However, this body of research also suggests that simply turning students loose in a computational microworld is a poor instructional strategy. (Kirschner, Sweller, and Clark 2006; Shaffer 2006) A key component in turning activity in a microworld into understanding in the real world is reflection: a student's ability to step back from what he or she is doing and talk with peers and mentors about what worked, what didn't work, and why.

In this paper we are interested in the role of adult mentors in an epistemic game. An epistemic game is a game based on professional practices, in which players learn by going through the same professional practicum process as professionals in training. In particular here we focus on the epistemic game Digital Zoo, and look at whether the mentors in the game contribute to the development of players' understanding of engineering.

Theoretical Framework

In his book *Educating the Reflective Practitioner*, Schon (1987) describes the process of becoming a professional as a process of alternating action and reflection-on-action. In professional practica, mentors facilitate this reflection, through meaningful dialogue with novices. So we can think of Schon's process of becoming a professional as action followed by meaningful interaction with mentors (Shaffer, 2006). For example, in order for novice engineers to become fluent in the engineering design process, they alternate between design and conversations with Design Advisors or Clients, in which they reflect on design decisions.

A professional develops a set of skills, knowledge, identity, values and epistemology that is specific to their practice (Shaffer, 2006). Becoming an engineer means acquiring the epistemic frame of an engineer (Svarovsky and Shaffer, 2006). In the game Digital Zoo, players participate in specific engineering activities: they receive a design task for which they brainstorm their ideas, develop design alternatives, test them, and choose which designs to recommend. Participating in these activities, which are modeled on the activities of a professional engineer, establishes the groundwork for players' epistemic frame development. In this paper, we examine whether meaningful interactions with mentors throughout this process are essential to players' abilities to acquire the frame.

Methods

We recruited 18 fourth and fifth grade students from a school class to play Digital Zoo for nine hours over the course of three days. Players designed wire-frame prototypes of characters within a computational spring-mass modeling environment for a fictitious upcoming animated film. They worked in teams with adult Design Advisors, and the game concluded with each team of players presenting their design recommendations to Clients.

In order to assess what players learned during the game, we conducted clinical pre- and post-interviews with each player. We coded a set of six questions about the engineering frame that were identical in pre- and post-interviews for 12 elements of the epistemic frame of engineering: the set of skills, knowledge, identity, values and epistemology that engineers develop in their professional training.

We used epistemic network analysis to construct a weighted network graph representation of the pre and post epistemic frame for each player by computing a separate adjacency matrix, a, for the pre- and post-interview responses of each player. Each element of the matrix $a_{i,j}$ was determined by the presence of frame elements e_i and e_j in the frame questions Q_k for a player's pre- or post-interview by the *co-occurance formula* (1). We then computed the weighted density D of each player's pre- and post-epistemic frame (2) and determined whether or not the weighted density of each player's frame increased between pre- and post-interview.

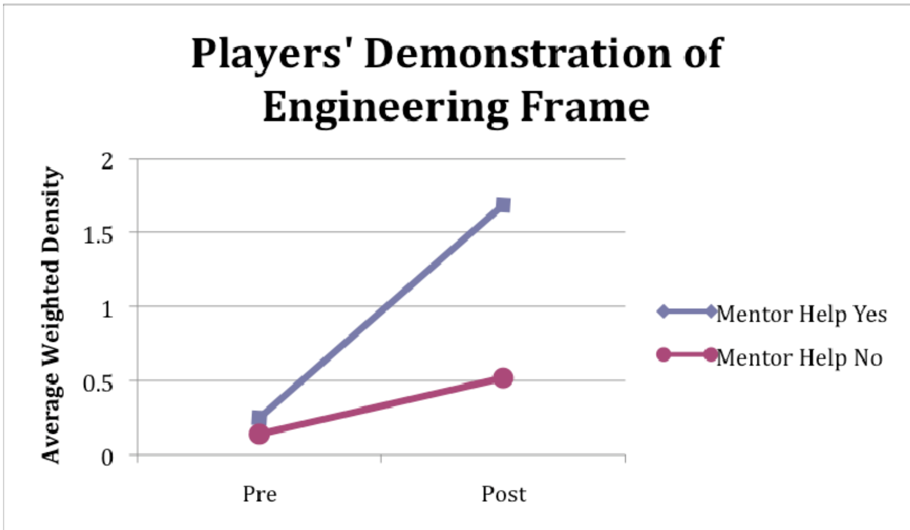
(1)	(2)
$a_{i,j} = \sum_{k=1}^{6} \left\{ \begin{matrix} 1 & if & e_i \in Q_k & and & e_j \in Q_k \\ 0 \end{matrix} \right\}$	$D = \sqrt{\sum_{i,j} \left(\frac{(a_{i,j})^2}{2} \right)}$

We examined two questions from each player's post interview that asked about their experiences working with the adult mentors who played Design Advisors and those who played Clients in the game. We coded for *meaningful mentor interactions* when a player reported that the adult mentors helped them to think about their designs or themselves and their job differently.

Results

Here we present three results from this analysis:

1. The mean weighted density of the epistemic frame graph for players increased significantly from pre (mean=.207) to post-interview(1.237, p<.01).
2. Out of 18 players,11 reported meaningful mentor interaction.
3. Players who reported meaningful mentor interactions were significantly more likely to show a positive change in weighted density (p<.05).



Discussion

The players in Digital Zoo who reported that the design advisors and clients changed the way they thought about their designs were significantly more likely to demonstrate an increased understanding of the engineering frame by the end of the game. Thus, we conclude that, in Digital Zoo, adult mentors with expertise in the game's domain play a key role in helping players understand engineering.

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Player-mentor interactions in an epistemic game: A preliminary analysis

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Introduction

Epistemic role playing games prepare young people to solve real-world problems by developing the epistemic frames of professionals (Beckett & Shaffer, 2005; Hatfield & Shaffer, 2006b; Svarovsky & Shaffer, 2006). To accomplish this, epistemic games feature frequent interactions between players and adults in the roles of *professional mentors* (Shaffer, 2006a). Here, we examine this mentoring role by measuring the extent to which players' epistemic frames come to resemble mentors' frames during these interactions.

Theoretical Framework

In professional communities of practice, mentors play an essential role in the learning and development of novice members (Lave & Wenger, 1991). In professional training experiences, or practica, novices engage in simulations of the kinds of professional problem solving they will encounter as experts, interspersed with guidance from more experienced mentors (Schon, 1987). Mentors help novices develop the *epistemic frame* of the practice: the collection of skills, knowledge, identity, values, and epistemology that shape professional thinking (Shaffer, 2006). Key to the concept of an epistemic frame, however, is that frame elements are not simply isolated components of practice, but are linked to one another in a systematic way to create a coherent professional vision (Goodwin, 1994).

An epistemic game is a game based on professional practices, in which players learn by going through the same professional practicum process as professionals in training (Shaffer, 2006). In this study, we look at the epistemic game Urban Science, in which participants play the role of urban planners and are aided by mentors called planning consultants. We focus on how planning consultants shape the epistemic frame of players in the game—and how this process can be uncovered through epistemic network analysis.

Methods

We recruited 15 middle school students to play Urban Science for 80 hours during the summer. In the game, players redesign three neighborhoods in their city. They conduct background research, physical and virtual visits, create preference surveys to solicit stakeholder feedback, and complete final plans for redevelopment of the city. Four graduate students served as planning consultants. In this mentoring role, they met regularly with players to reflect on their work as planners.

Data

These regular interactions were recorded, transcribed, and coded for the presence of elements of the epistemic frame of urban planning: the skills (strategies for accomplishing planning tasks), knowledge (use of planning terms of art or discussion of cities as systems), identity (talk of feeling like a planner or professional), values (talk of what things are important to planners), and epistemology (talking about or engaging in the substantiation of claims).

Data analysis

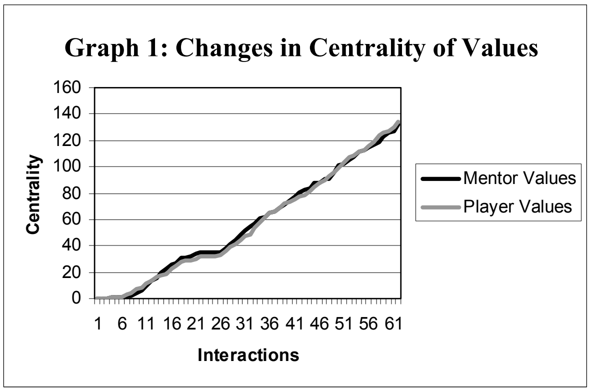
To analyze the linkages between frame elements over time, we computed two sets of adjacency matrices, p_i and m_i, representing the co-occurrence of frame elements in each interaction i in the utterances of either players (p_i) or mentors (m_i). We then computed the centrality of each frame element e following interaction i, for players (P) and for mentors (M) as:

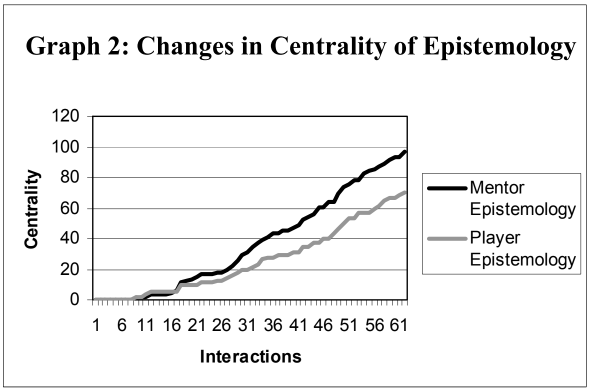
$$P_i^e = \sqrt{\sum_j \left(p*_{e,j}\right)^2} \text{ where } p^* = \sum_{j=1}^{i} p_j \text{ , and similarly for } M \text{ and } m.$$

We then compared changes in P and M over the course of the game for each element of the frame.

Results

The elements of the players' epistemic frame and the elements of the mentors' frame together become progressively more central. For example, changes in the centrality of values in the players' frame followed closely changes in the mentors' frame (see graph 1). The progression of relative centrality of each frame element was not always the same for the mentors and players, as in the changing centrality of epistemology (see graph 2). However, even when there is a lag, the slopes for both the mentors and players increase consistently and similarly through the game, suggesting that with more time the centrality of the frame element of epistemology would continue to increase.





We thus conclude that in this game, by sharing the discourse of urban planners with planning consultants in the process of facing real planning problems, players began to internalize the epistemic frame that characterizes the planning profession and that was enacted in the discourse of the planning consultants. Moreover, since the adjacency matrices p and m represent not isolated frame elements but linkages between frame elements, the similarities in centrality of frame elements over time in P and M suggests that players internalized not just isolated elements of professional discourse but a systematic pattern of practice characteristic of the epistemic frame of urban planning.

Limitations

This study is clearly preliminary in nature. We analyzed frame elements at a relatively coarse level of granularity, and in subsequent work plan to examine how specific aspects of the skills, knowledge, identity, values, and epistemology of planning are linked through player-mentor interactions during game play. Because players interacted with different mentors and worked in different teams throughout the game, in this study we examined the collective frame of the mentors and the collective frame of the players. In future work we plan to conduct a more detailed analysis of the development of the frame in individual players through their unique interactions over the course of the game.

The results of this preliminary look at the interactions between mentors and players suggest that such further investigation is warranted.

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