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Hypermedia-Based Tutoring

Methodology for the production of hypermedia resources through face-to-face tutoring

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Abstract—We present a methodology for creating hypermedia materials derived from face-to-face tutoring sessions between a tutor and graduate students. To create the hypermedia materials, the tutor and the student used a smart pen which allowed to record the conversation and digitalize the notes being taken. The production of hypermedia material is based on the use of visual representations and text to help students go from concrete to abstract thinking and vice versa. We point out that hypermedia materials are audio-visual narratives (i.e., dynamic graphics, diagrams) that facilitate the representation of co-constructed shared knowledge and let participants navigate between oral and textual information. This methodology allows the production of individualized material without investing additional time in editing and designing. The hypermedia based tutoring (HBT) model is highly valued by students since it helps them to go over the discussions with the tutor and review the thinking process that both constructed during the session. HBT becomes a creative form of communicating and representing information that challenges the tutor and student to develop new skills and ways of thinking. The model that we propose here requires to change traditional tutor and student roles and to create learning experiences that do not overlook students' needs.

Keywords—hypermedia-based tutoring; hypermedia resources; face-to-face tutoring; smart pen; communication; learning

I. INTRODUCTION

The tutoring model we present derives from our experience working with graduate students in their master theses and dissertation. As part of this experience, we engaged in dialogue and used a smart pen to generate multiple graphic techniques that enhanced the learning process. We used concept maps [1], V diagrams [2], schemes and other graphic knowledge organizers [3, 4] to help students reflect on their research topics and engage in higher thinking operations. We recorded the tutoring sessions with the smart pen, which in turn allowed us to create hypermedia materials to mediate the learning process.

A previous investigation [5, 6], in which 103 tutoring sessions with 26 graduate students were analyzed, helped us identify a typology of hypermedia materials and the educational value that students attached to the use of such

materials. Students revised the materials repeatedly to analyze concepts, verify instructions from the tutor, and monitor their own learning. The assisted reflection in which students engaged through the use of hypermedia materials led them make decisions about their research projects. These particular findings suggest that students benefit from having supportive materials that join the tutoring sessions and that can be revisited at any time after the session with the tutor has ended. The discussion of concepts, procedures, and specialized information that tutor and students discuss during the tutoring session is not always an easy process and sometimes students need additional time to understand what they need to do. Tutoring that integrates the use of technology can work as cognitive scaffolding [7].

We present a tutoring model (hypermedia-based tutoring [HBT]) that involves the creation of hypermedia materials for graduate students. During face-to-face sessions, the instructor and student put forward questions, ideas, and strategies to address specific learning gaps. Through the interaction and dialogue in which student and professor participate, they co-construct individualized material.

The production of hypermedia material is based on the use of a particular type of communication that uses visual representations and text to help students to go from concrete to abstract thinking and vice versa. Hypermedia material primarily consists of audio-visual narratives. This particular type of narrative is based on a set of audio notes and graphical representations that the tutor and the student co-construct as a result of the on-going dialogue underlying the face-to-face tutoring sessions. In their attempt to address a specific learning gap (e.g., how to write a literature review) related to their research projects, the student and the instructor formulate and answer questions, use analogies or metaphors to illustrate a point, explain concepts, and discuss graphic representations.

As part of the HBT, the tutor and students build audio-visual narratives by using a *Livescribe Echo* smart pen. Both the instructor and the students can use the pen simultaneously. This smart pen digitalizes the notes, graphics, and diagrams that are represented on a special paper in a notebook. Simultaneously, the pen records the explanations that

supplement the notes and creates an audio file. The created audio and image file can be transferred from the smart pen to the computer as a PDF file, which can be easily shared between tutor and students. Participants can use a specialized application (i.e., on-line player) that comes with the smart pen to access the synchronized audio-image file. The created digitalized image (i.e., file) is a computer-based record of the face-to-face tutoring sessions, the information, questions, and issues discussed by the instructor and the student.

Recent studies have shown that students benefit from the use of hypermedia-based tutoring [6]; therefore, it is important to further analyze the processes through which individuals experience learning when using innovative forms of knowledge representation and construction.

In the following sections of the paper we first describe the study's conceptual background and approach (i.e., technomethodology). Then we present the procedures for the creation of hypermedia materials and the components of the hypermedia design. Finally, we draw some conclusions.

II. BACKGROUND

In face-to-face tutoring sessions, the tutor's main role is to facilitate learning experiences by providing a stimulating context (e.g., formulating questions) and encouraging the development of critical thinking and metacognitive skills. As a result, we define the *tutor* as a mediator of learning. Each one of the face-to-face tutoring sessions is an opportunity for the construction of communicative interactions in which both the tutor and the student can restructure their cognitive schemas.

Although several studies have defined the notion of *tutor* in multiple ways (i.e., mentor, advisor, director, or guide), we aim not to move a debate about the conceptualization of the term but to position ourselves within a particular framework that serves to highlight the mediating role that the tutor plays in triggering student learning. According to Vygotsky's theory, human speech is the central system of social interaction, which is based on communicative interactions [8]. Other systems that mediate human thinking and interaction include writing, graphics, and mathematics. All these systems facilitate both the creation and preservation of multiple meanings, which are the foundation of learning.

In educational processes, tutors become learning mediators by developing activities, formulating questions, modeling procedures and strategies, providing guidance and support, and creating a trustful atmosphere where students can engage with knowledge effectively [9]. In HBT, the tutor creates a three-dimensional mediation to encourage learning. The first dimension involves reciprocal dialogue, which is a two-way form of communication based on the mutual acknowledgement of needs and strengths. Dialogue helps to build a trustful context to present specific concepts, theories, and conjectures. The second dimension refers to the development and use of graphic representations that are presented along with metaphors, demonstrations, and specific information. The third dimension consists of an integrative logic that aims to help students to make sense of the relationship between the various parts of the dialogue: concepts, graphics, and metaphors.

The type of tutoring intervention model that we present here responds to the specific context and needs of the students who engage in the dialogue with the tutor. The end products (hypermedia materials) are highly personalized as they represent the students' unique research topic and questions. As a result, it is difficult to transfer the materials to other students. Students and tutor co-author the hypermedia materials according to the specifics of the dialogue occurring between them. Since the hypermedia materials are customized for each student, the HBT responds to the diversity of interests and needs that each student brings to the tutoring session.

Aguilar-Tamayo's study [5, 6] showed that students used the hypermedia materials repeatedly to ensure an effective understanding of the tutoring sessions and maximize the use of feedback they obtained during the sessions. Aguilar surveyed students who engaged in HBT and used hypermedia materials during 36 months to identify the strategies they used to read and review the material. Aguilar-Tamayo found that students use several of the following strategies:

- Play the audio of the tutoring session from beginning to end, without forwarding or going back.
- Take notes while the audio of the tutoring is being played.
- Compare the notes taken during the tutoring (by the student) and the notes recorded as part of the conversation between the tutor and student.
- Either forward or rewind the audio of the tutoring to check specific segments of the conversation and verify the use and explanation of concepts.
- Print the notes for further revisions.
- Save the tutoring links for further review.

The use of one or several of the strategies listed above allowed students to engage in reflection, which promoted a deeper understanding of concepts and tasks associated to the development of their theses and dissertation [10]. The reflection process in which they engaged ultimately led to new forms of interpretation, new insights, and further questions [11]. Since the students reported benefits in the use of this type of tutoring model and the use of hypermedia materials, we infer that the model is pertinent to promote learning among graduate students.

III. TECHNOMETHODOLOGIES: THINKING ABOUT THE INTEGRATION OF TECHNOLOGICAL ARTIFACTS AND HUMAN ACTIVITY

Technomethodology is an approach based on the development of processes and procedures through the interconnected use of technological and cultural artifacts. The development of the HBT model incorporates a technomethodological approach. HBT is not the adaptation of technology to a fixed series of activities but the redefinition of a learning environment in which dialogue is enhanced and preserved by the use of technology to enrich learning activities that enable the student and the instructor to modify cognitive schemas and metacognitive skills.

The creation of hypermedia materials from the reciprocal dialogue between instructor and students redefines the tutor's role. In this new context, the tutor becomes a learning mediator whose expertise facilitates the presentation, representation, and communication of information and forms of thinking.

The implementation of a technomethodological approach in the production hypermedia materials is relevant because it challenges traditional approaches in which technology dictates the direction and characteristics of the interaction process in education. What we suggest here is that technology does not have to be the starting point or dictate the characteristics and direction of social interaction. The opposite is recommended: the form and style of the interaction determines the relevance and use of technology as part of the social and learning process. The use of technology and the production of hypermedia materials that emerge from intertwined or co-occurring forms of thinking (i.e., inter-thinking) between participants. Tutor and student thinking together and use technology to learn and create new meaning.

The process of building hypermedia materials is not a spontaneous event but the result of purposeful shared thinking and the definition of a clear goal: to reflect on concepts and methodological decisions related to the development of the research project. Additionally, the creation of the hypermedia materials allows the systematization in the mediation of learning.

The HBT model allows participants to represent, in the note taking process, the theoretical and methodological knowledge related to their research project. The final product is a recorded set of data (hypermedia materials) built from the information that tutor and students discussed during the sessions. The saved data allows to track the evolution of ideas and the emergence of questions. The final product will enable participants to intuitively navigate through the recorded sessions to achieve further understanding about specific topics.

The tutor and student's experience and skills have an important influence in the quality of the hypermedia materials' structure. The more experience the tutor and student gain with the use the smart pen and the implementation of the HBT model, the more refined and effective the structure of the sessions become. The structure of the sessions can be flexible to allow the diversity of questions and needs that the students have.

A key aspect in the structure and content of the hypermedia material (audio-visual narratives) is the use of graphic techniques to convey meaning and trigger understanding among students. Graphic techniques include concept maps, tables, titles, lines, figures, divisions, sections, and schemes that are helpful to show relationships between concepts. Graphic techniques are organized in the notebook's page and they become a sort of map that allows the navigation of the tutoring session. When the student clicks in a particular area of the notebook's page, he is taken to the segment of the audio-visual narrative.

Through this model, we want to emphasize that a technomethodological approach is based in the idea that technology

becomes both the product and the means: Technology can mediate the process of learning and, at the same time, learning creates certain types of technology that can contribute in the development of further learning experiences.

IV. METHODOLOGY FOR CREATING HYPERMEDIA MATERIAL

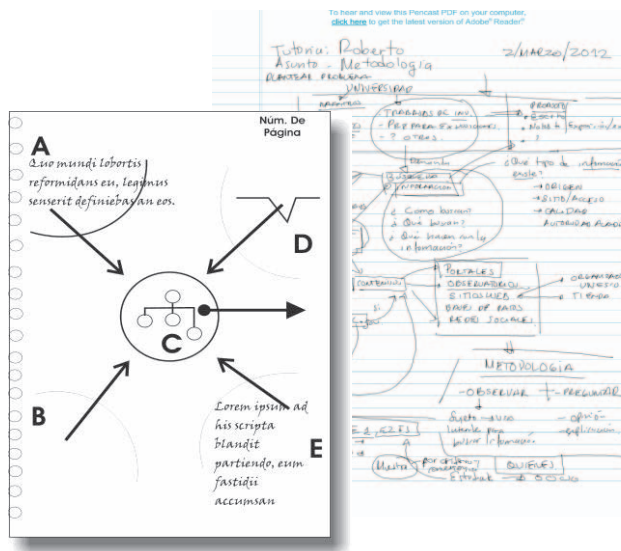
The hypermedia materials (audio-visual narratives) are the result of the development of face-to-face tutoring sessions, which are expected to unfold in the following order:

- Beginning of the session: The student presents any questions he or she has (i.e., learning gaps) in relation to his research project. The instructor listens to him or her and also asks a series of questions in order to find out more about the students' needs. Based on the students' input, the tutor starts developing opportunities for shared reflection. At this stage, the instructor takes notes about the concerns stated by the student and he starts developing notes and graphic designs to answer the student's questions. The outcome is a series of ideas and questions to be addressed as part of the tutoring session. The session can generate two or more pages of hypermedia material.
- Development of the session: Through dialogue, the tutor and the student build graphic strategies and short notes derived from the discussion of concepts and conjectures. Previous studies have shown that graduate-level tutoring has adopted the use of graphics to represent specific ideas. The regularity in the use of explanatory argumentation has been called *model pages* [1].
- End of the session. Once the tutor and student have broadly discussed the existing questions related to the development of the theses or dissertation, the session ends by drawing some conclusions and making explicit what the commitments and assignments to be done after the session are. The end of the session also allows participants to verify whether or not the goals of the sessions were fulfilled.

In audio-visual narratives (hypermedia narratives), metaphor and schemas are resources that can promote learning. Throughout the tutoring session, the tutor uses a pedagogical style of writing based on the use of metaphors and schemas. The zoomed diagram in Figure 1 aims to address some of the learning gaps reported by the student. The sheet in the background shows some of the notes taken by the tutor during the session. Although the speech sequence (the recorded audio) is linear, the audio-visual narrative (particularly the diagrams) highlights the multi-dimensional and non-linear discussion of topics or themes (represented in Figure 1 as A, B, C, D, E) for students.

The construction of the audio-visual narratives (hypermedia materials) mediates the learning process and the development of specific forms of shared knowledge. The notes taken during the tutoring sessions do not necessarily represent a formalized individual thinking but the in-progress version of shared thinking. The graphic techniques used during the tutoring sessions mediate thinking [12]. The notes created by the tutor and student become a public text that is available for further reading and interpretation [13].

Fig. 1. Example of the Model page. This graphical organization represents, at the same time, a particular type of structure in the narrative organization. There can be different narrative models according the purpose of the explanation during the tutoring session.



The representation of metaphors is another strategy that can be incorporated in the construction of the audio-visual narratives. The representation of metaphors can be done by using specific figures and lines, whose purpose is to help students identify how external figures (i.e., metaphors) help them respond to specific questions related to their theses and dissertations.

Schemes are critical elements of the audio-visual narratives. The characteristics and relevance of the schemes depends on the purpose of the tutoring session and the type of students' questions being explored during the session. A concept map for example is a type of graphic tool to represent the complexity of the relationship among concepts and multiple levels of abstraction [14].

In multiple cases, the audio-visual narratives include the representation of a multi-stage process(es). In these type of cases, both the tutor and the students have to work on the development of a graphic solution that helps them to explain and understand the unique features of the process as a whole and the specific stages too.

The use of graphic representations aims to make a particular concept, set of concepts, or process particularly more accessible to students. Thus, schemes and any other type of graphic solutions are not only visually attractive resources to trigger learning but also pathways to enrich conceptual understandings [15]. In multiple disciplines, schemes or diagrams are used as heuristics to deconstruct a concept or idea, a process, or an argument. For example, in biology we found diagrams representing a flower, organs and systems in the human body, or ecosystems [14].

V. HYPERMEDIA DESIGN

The characteristics and functions of audio-visual narrative (hypermedia narrative) are based on two discursive logics. The first is the graphic discourse or graphic organization of the explanatory argumentation. The second is the linear, oral account that is produced by the tutor when he or she tries to help the student understand a particular point. The graphic organization joins the linear oral account to enable more complex ways of thinking. The co-construction of communicative interactions during the tutoring sessions also allows the use of non-linear expressions, which include shared cultural understandings that are represented by graphic metaphors, as well as literary metaphors that are a first step for facilitating (a) inter-textual relationships between ideas and specific contents [16], and (b) intra-mental relationships between instructor and student [17].

When the student reads the hypermedia material, graphic representations and other text markers, such as titles, circled words and highlighted sentences help the student to recall and analyze the session (Figure 2). According to their reading ability and skills, students may make either basic (go over a specific section to remember definitions, instructions, references) or sophisticated (analyze the interconnection between ideas, instructions, and references) uses of the hypermedia materials that shape the audio-visual narrative.

Fig. 2. Time line and hypertextual reading.

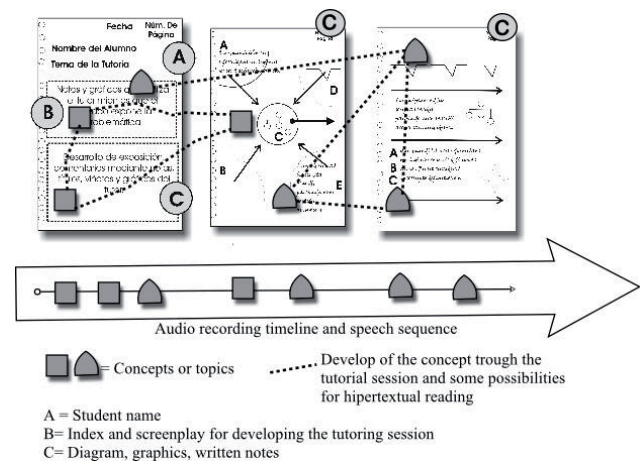
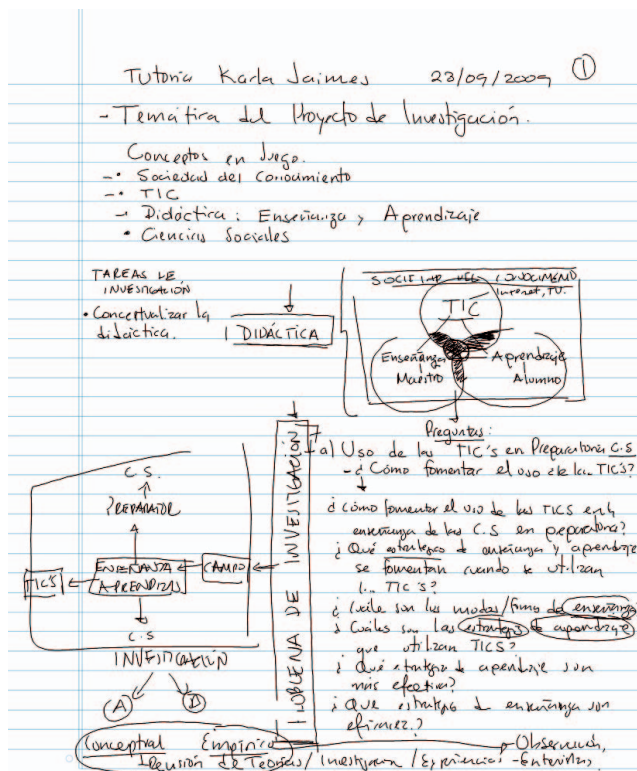


Figure 3 is an example of a finished audio-visual narrative; we present the visual aspect of it. Some readers may find the notebook page as difficult to read or disorganized. However, when we add the audio to the visual elements, the student can follow the explanation that is provided during the tutoring session. The graphic organizers (as well as additional notes) and audios appear in the computer screen simultaneously.

Figure 4 shows an example of the way in which the audio-visual narrative displays in the computer screen. The A section, which is in grey font, suggests that once the audio connected to that graphic element is played, then that section will become bold (black font). Once the audio-visual narrative is fully presented (uploaded) in the computer screen then the

student can review the co-constructed knowledge and interpretations that he and the tutor have created. It is possible that after reading the audio-visual narrative again (of after reading it multiple times), the student will come up with additional questions. The additional questions that arise can be the reason to schedule the next tutoring session.

Fig. 3. Content and design of the page.



Depending of the needs of the students and their reading skills, they can navigate the audio-visual narratives in different ways. Students can read and use the graphic elements of the audio-visual narratives differently, to access different sections of the narrative (Figure 5).

The lineal reading of narratives involves reading the narrative at the same time that one listens to the audio and pay attention to the way in which the graphics are linked to the explanation to convey a specific meaning. In figure 5, the dotted line with stars shows a potential direction to read the narrative, starting from a particular concept in the notebook. In this example, the reader would navigate among different graphic elements and words to understand the evolution or explanation of a concept in the conversation.

To summarize, we argue that hypermedia materials are audio-visual narratives (i.e., dynamic graphics, diagrams) that facilitate the representation of shared thinking and a thematic hierarchy. The use of hypermedia materials let participants navigate between oral and textual information. The various figures that we showed in this section illustrate multiple examples of audio-visual narratives, the types of conversation

that tutor and students can create, and the potential ways in which students can navigate those narratives.

Fig. 4. The progressive display of the writing image

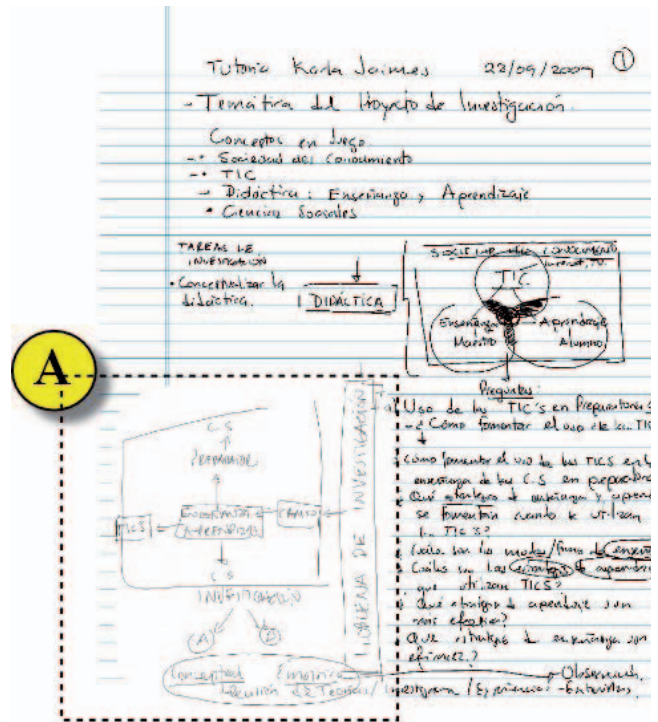
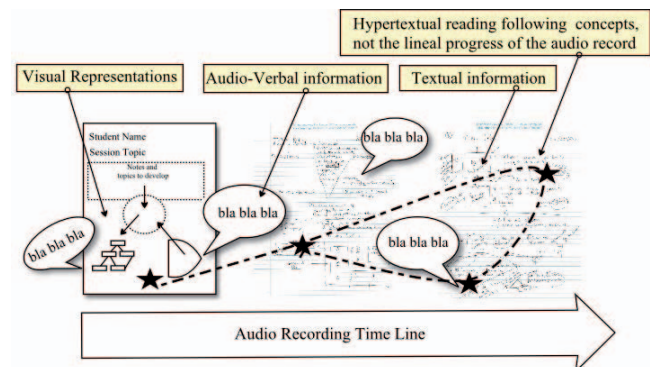


Fig. 5. Hypertextual reading and the integration of verbal, graphical and textual information.



VI. CONCLUSIONS

HBT represents the creation of new educational resources that result from the redefinition of roles in the student-tutor relationship. HBT also encourages more creative forms of communicating and representing information; this model challenges the tutor and student to develop new skills and ways of thinking. Additionally, the construction of a computer-based file derived from the face-to-face tutoring session facilitates the storage and recording of the learning mediation process. The tutoring session can be stored and retrieved at any time and for multiple purposes. An important

limitation of the HBT model is the exclusive reliance on a particular commercial product (smart pen) for the development of this methodology.

The HBT model facilitates the construction of hypermedia materials that are responsive to students' learning needs. The effective implementation of the HBT model depends on the development of communicative and tutoring skills in the professors and the graduate students themselves. The tutor's understanding of the learning process and the skills he possesses as an educator and researcher are crucial to guarantee the production of high quality hypermedia materials. The HBT model advocates for an enriched understanding of the tutor's role and the tutoring process in graduate education. This study also suggests that professors may need to be trained to perform their tutoring roles more effectively.

Likewise, the implementation of the HTB model requires certain forms of technological support that are fundamental to not only store but also make the materials available for the students. Professors would need to rely on some sort of data storage that is backed up by the department or institution. If professors can store and upload the tutoring sessions that they develop with their students, then the department or the institution can use the digital files as evidence of the tutoring practices in which faculty and students participate. In multiple cases, accreditation agencies request that programs present concrete evidence of the promising practices implemented by faculty.

A limitation of the HBT model is the exclusive reliance on a particular type of technological device (the smart pen). The production of the hypermedia products is largely defined by the functions and format that *Livescribe Echo* smart pen provides.

As technological options continue evolving, we would consider the use of other devices to assist the tutoring of graduate students. At this stage, the use of the smart pen provides an effective solution to create materials that mediate the processes of both self-directed and collaborative learning.

Further investigation involves the analysis of the experiences using the smart pen in educational activities that go beyond the tutoring process. As part of our experience, the smart pen has been used to take notes during the evaluation of students' oral presentations of their dissertation's stages of development. Once the student finishes his presentation he can obtain immediate feedback related to his performance. While the student is presenting, the tutor can use the smart pen to record what the student is presenting and, simultaneously, make notes about the strengths and weaknesses of what he is presenting. The professor can save and share the digital file with the student shortly after the presentation. When the student explores and analyzes the file, he can identify his performance in terms of organization, clarity, coherence, and depth. The analysis and systematization of practices that involve the use of the smart pen can improve our understanding of the tools to enrich the educational processes at the graduate level.

This study is a significant step in the analysis and formalization of technology-mediated practices in graduate

education. Additionally, we seek to expand the use of the HBT model to other educational scenarios as a strategy to identify areas of improvement in the suggested techniques and to overcome identified limitations.

The elements and process of the HBT model continue to evolve according to the new developments in the context of tutoring practices in other disciplines and knowledge fields. The possibilities to innovate special pedagogical strategies, such this, one depends on the ways in which representational models and communication processes continue to be analyzed as part of the educational experiences at multiple educational levels.

Four fields of knowledge contribute to understand the foundations of the HBT model. The first one refers to theories that seek to explain systems of representation as part of the cultural artifacts that are socially available. This dimension emphasizes that representations have evolved historically and are embedded in the cultural and scientific practices of society [14].

The second dimension that informs the HBT models involves learning and epistemological theories. HBT is fundamentally defined as a cultural artifact that integrates systems of representation to facilitate assimilation and knowledge construction. Cultural psychologists provide insights to better understand the ways in which individual perform certain psychological (cognitive) functions within specific social cultural contexts.

The third dimension, which is the one this article emphasizes, is related to techno-methodology. This field of research seeks to promote knowledge construction and knowledge sharing through the hypermedia representations. The HBT model is an intentional and purposeful set of actions aim to create useful learning materials which integrate epistemological principles that underlie the acquisition and construction of knowledge.

The fourth dimension is the field of professional development and psycho-pedagogical intervention. The implementation of the HBT requires the understanding and innovation of instruction and the management of educational practices. Primarily, the HBT model involves the development of effective pedagogical strategies that guarantee student engagement, metacognition, and dialogical relationships. This study attempts to make explicit the series of principles that define this model to make it accessible for different cultural contexts, technological tools and disciplines.

Nowadays, there is a limited understanding of the tutoring process at the higher education level; it is mostly reduced to the scheduling of meetings in which there is no a formal definition about the roles and expectations that participants should enact during the meeting. Additionally, participants do not discuss how the student can further utilize the discussion and material used addressed during the session. There seems to be an implicit understanding, among university professors, that tutoring sessions are a standardized practice in which the student talk, the professor listen and vice versa. The HBT model aims to emphasize that each student needs

individualized attention and each session demands different learning mediation acts.

The implementation of the tutoring practice relies on the use of written forms of communication (email, discussion forums, collaborative documents, cartels, etc.) in addition to specific technological tools that help store shared materials. The construction of these written forms of communication tend to happen in more spontaneous, without a more formal systematization and use of educational/epistemological techniques. The HBT model tries to address such a gap and to make tutoring practice a more systematized educational/learning experience.

Students' ability to read and write is fundamental in graduate school. Therefore, the tutoring process should not only use but also maximize the development of these abilities. Explaining, questioning, demonstrating, and arguing are processes that can be refined through the dialogical interaction and the systems of representation that the HBT model suggests. Hypermedia allows users to diversify the creation and acquisition of knowledge.

The HBT model does not attempt to eradicate the use of other systems of representations and forms of interaction between tutor and students. Rather, the model seeks to integrate, in a more systematic and intentional fashion, patterns of communication and learning that are effective at the graduate level [6].

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