NARRATOLOGY AND LUDOLOGY: COMPETING PARADIGMS OR COMPLEMENTARY THEORIES IN SIMULATION

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ABSTRACT

Technological innovations in simulation practice have increased the speed at which theories underpinning their study evolve. As researchers come forward to accept the task of developing these theories, differences between two philosophical positions – narratology and ludology – are sparking debate which may indicate a future paradigmatic shift. The article to follow compares and contrasts narratology and ludology within the range of simulation and non-pedagogical gaming, respectively. Divergences between the two holistic meanings are noted, overlap and synergies between the issues surrounding these meanings are discussed, and a fusion of the two is proposed for future theoretical and/or paradigmatic progress.

INTRODUCTION

Established ways of seeing the world are replaced, throughout history, by tremendous upheavals in thought. Those changes are so expansive that the old ways of thinking are totally incompatible with the new. To embrace the new is to undertake a conversion experience. By no means are all scientists in the field willing to contemplate this move from a comfortable stability. – Burrell, 1996, p. 646

To many simulation designers, scientific philosophy matters may seem perfunctory and boring when compared to the exciting state of current practice. Advances witnessed over the past decade have ushered in a wide range of industry innovations and explosive growth in research inquiry. These advances sharply contrast, however, with our "rudimentary, underdeveloped state of theory" (Klein & Herskovitz, 2005, p. 303). Even worse, perhaps, is the rootlessness of our theory. Few to no works attempt to identify our paradigms in simulation research. Without clear paradigms to guide us, our inquiries are limited in ways we may not be aware of.

Two philosophical positions have been examined in the literature surrounding simulation and gaming: narratology and ludology. Narratologists are scholars who generally claim simulation and gaming are closely related to narrative – or "stories" – analyzing them through this lens to explain both their inner workings (Frasca, 2003a), and the workings of individual mind (e.g., Bruner, 1960; Schank, 1990). Ludology, in a similarly broad regard, focuses on the interactivity, structure, and play in simulation and gaming (Frasca, 2003a). Ludologists generally contend that the fidelity, immersibility, and "realness" of the experience are more important than narrative elements.

Games are typically defined as settings designed for participant interaction bounded by certain rules and processes. Gaming, a related term, refers to the interactions themselves among players in multiparticipant games (Hsu, 1989). Pedagogical gaming centers on learning, whether this learning serves industry, education, or the participants themselves. Management games, for example, typically serve the needs of industry (Greenlaw & Wyman, 1973). They are pedagogical in nature, less interested in play, and more interested in learning as the end goal. Historically, pedagogical gaming was turn-based in nature; but changing technology is increasing the development of more dynamic and continuous designs.

Non-pedagogical gaming centers on play more than learning. Videogames, for example, first try to attract participants, then pull them into the medium and encourage them to engage and interact with it. While participants in non-pedagogical gaming must learn the rules of the game and the rewards for particular actions, the end goal is not primarily based on learning. Instead, affective states such as pleasure and enjoyment are targeted.

Simulation and gaming researchers have yet to reach consensus on which set of theories – narratology or ludology – is of most use and benefit to continued progress. These researchers fall mostly in one of the two camps, and never the twain shall meet. As a result of their either/or way of thinking, the controversy is heated instead of enlightened (Bernstein, 1983; Martin & Kleindorfer, 1991). This parallels the difficulty that simulation and gaming designers

themselves have fought for decades in combining high-quality, high-power stories and interactivity (Manovich, in Frasca, 2003b). Influential voices in the debate between these schools of thought have attempted to silence it (e.g., Frasca, 2003b), but the rift remains. Thus we reopen the debate below, showing how narratology and ludology are two equally valuable sides of the same coin, whether that coin is paradigm or theory.

The following discussion systematically explores the two camps of narratology and ludology within the context of simulation and gaming. First, we present a brief rationale for transferring the debate from non-pedagogical gaming studies to pedagogical simulation – a process which has already begun (see Bizzocchi & Woodbury, 2003). Second, the semantic confusion of simulation and gaming will be addressed. Next, narratology and ludology will be defined and followed through the literature, focusing on theoretical and conceptual works relevant to the debate. Last, we examine paradigmatic issues, to determine if the debate is a paradigmatic shift from old or nonexistent to new. Finally, we summarize the overall findings, concluding that the two elements are inseparable parts of a new paradigm for simulation and gaming.

THE GREAT DEBATE

The narratology versus ludology debate has been going on for over two decades in the non-pedagogical game community – mostly in reference to videogame, virtual reality, and hypertext. The earliest published work specifically targeting this squabble surfaced in 1982 (Csikszentmihalyi), and it continues today. Many gamers have become overwhelmed, even worn out, by the exchange of ideas:

- Bottom-line, I see this debate as a pointless distraction that has pulled a lot of smart minds into its depths. In effect, there is not conflict between the two camps. The ludology camp is perfectly correct, and how this can be argued is beyond comprehension (Miller, 2005, ¶ 1)
- We have already had more than one paper or presentation that attempted to be the "Last Word" on the debate, which of course signals that despite the best intentions, we haven't reached the last word on narratology vs. ludology yet (Young, 2005, ¶ 1)
- We're pretty much all… sick to death of hearing the tired old duality brought up (JP, in Juul, 2004, ¶ 5)

The pedagogical simulation literature is not too far removed from this conflict, however. We learn from each other's progress, adopt each other's tools, and build on each other's research; thus dialogue between our respective groups may hasten the paradigmatic shift to come. Already, our articles reflect narratological or ludological perspectives – i.e., foci on sensemaking, the core model, content, and meaning as opposed to foci on fidelity, immersability,

cognitive prostheses, and interactivity. The specific paradox between narrative and interactivity in pedagogical simulation has been identified (e.g., Bizzocchi & Woodbury, 2003), and the technologies on which our practical innovations depend are shared. As we edge closer to game studies, we move closer to a collision with this debate.

DEFINITIONS AND SEMANTICS

To prepare ourselves, it is our next task to define simulation and gaming. For the purposes of our discussion here, we are concerned with computer simulation as a subcategory of experiential learning. There is rampant confusion in this task though, perhaps because simulation and gaming are becoming more complex, dynamic, and interactive; eroding the trademarks signs previously used to distinguish one from the other.

As quoted by Denton (1994), "Simulation, as used in training, is a dynamic representation of a system, process or task" (Rediffusion, 1986, section 1.3). By another definition, simulation is the set of "organizational devices for arranging interactions" (Roebuck, 1978, p. 107). Here, we define simulation as the behavior of a representational model which represents reality in some way (Van Horn, 1971). Games also have a core model, but many gaming definitions focus on the participants' interactions, bounded by the designer's chosen setting, rules and procedures (Hsu, 1989).

In the past, researchers in experiential learning have made calls for continued philosophical clarification (Ruben, 1999), as many have focused on the paradigms or theoretical foundations for instruction and learning practice (e.g., Kirkley & Kirkley, 2005; Ruben, 1999; The Design-Based Research Collective, 2003), but not those for simulation and gaming themselves. Here, we focus on the latter, excluding considerations of instruction and learning outside these areas.

At the core of simulation is a model which represents some part of reality. Other than this, however, its characteristics are mutable at best. For instance, continuous event computer simulation now rivals gaming in it ability to simultaneously accommodate multiple players (e.g., Two Comma Titans, 2005). In the future, the two differences between simulation and games – "the absence of an interpersonal element in computer simulation," and the presence or absence of "process focus" (Feinstein, Mann & Corsun, 2002, p. 739) – may be soon eliminated by technological innovations such as virtual reality and multiparticipant interfaces (Ong & Mannen, 2004).

The definitions' inherent volatility is why we do not here strongly adhere to rigid boundaries surrounding their meanings. This is not unusual, because when paradigms shift, construct definitions can and do change. As a consequence, we admit that possible overlap between the concepts of simulation and game makes investigating narratology and ludology all that more difficult.

NARRATIVE AND NARRATOLOGY

Narratology, or the study of narrative, traces as far back as Aristotle; and has been an idea present in toys and games since the beginning of their existence (Frasca, 2003a; 2003b). It covers a wide range of disciplines (e.g., organizational theory, drama, and literature), methodologies (e.g., discourse analysis), and epistemologies (Robichaud, Giroux, & Taylor, 2004). Its roots in the social sciences literature can be traced back to its application in this line of research centers on the models used to design computer simulation and game.

Narrative is a model for how individuals act (Cooren, 2000; Czarniawska, 1997), construct reality (Weick, 1995), think and learn (Bruner, 1960; Schank, 1990). It creates organization and meaning for everything that enters individual's brains through the acts of living, creating, or interpreting (Fisher, 1984, p. 2). Thus, narrative is the form in which we "organize our experience and our memory of human happenings" (Bruner, 1991, p. 4).

In short, narrative helps individuals construct knowledge through the process of recursivity (Robichaud, Giroux, & Taylor, 2004). Recursivity is the iterative process of learning, combining the processes of reflecting on information and socially constructing knowledge (Bowen, 1987; Denton, 1994; Hampden-Turner, 1971; Laveault & Corbil, 1990; Perry & Euler, 1988; Thatcher, 1986). In simulation, reflection is the proxy term often used to describe recursivity (Bowen, 1987; Gosen, 2004; Kolb, 1984; Thiaragajan, 1994). Learners engage with the model, or narrative, which is its core (Gosen & Washbush, 2005), constructing knowledge by engaging with the narratives of others and creating their own (Schank, 1990). Thus, the learner's interaction and engagement with computer simulation and game are crucial (Jones, 1989; 1990).

There are two main schools of narratology in the simulation and gaming world: expansionist and traditionalist. Expansionists have a hermeneutical perspective on narrative, viewing it as "a mutable concept that differs from culture to culture and evolves through history, crucially affected by technological innovations" (Ryan, 2001, p. 2). They deconstruct narrative, challenging plot, linearity and form in stories (Landow, 1997). While a hermeneutical approach has shown valuable in previous simulation inquiries (e.g., Kleindorfer, O'Neill, & Ganeshan, 1998), the main disadvantage of expansionist approaches is that they can deconstruct to the point where narrative ceases to mean anything at all (Ryan, 2001).

The traditionalist school sees narrative as "an invariant core of meaning, a core that distinguishes narrative from other types of discourse, and gives it a transcultural, transhistorical, and transmedial identity" (Ryan, 2001, p. 3). According to Ryan (2001), a traditionalist, a narrative is "the use of signs, or of a medium, that evokes in the mind of the recipient the image of a concrete world that evolves in time" (p. 4). A story is "the mental construct constitutive of narrative" (p. 5). This differs from discourse, which are the

"material signs" of the narrative. This approach's primary directive is to achieve interactivity with narrative – for example by letting an individual control a character.

While many equate narrative with oral or written storytelling – called the diegetic mode - there are several other modes of narrativity, which can exist in combination. Simulation and gaming are (1) participatory and (2) simulative in mode, meaning that they (1) allow a user to play a role, choose behavior, and create a story; and (2) design an engine that uses internal rules and input from the user to create a sequence of events that tells a story (Ryan, 2001).

Clearly, then, narratologists in the experiential learning sphere focus on the core model, or narrative, of simulation and gaming; but they also hold fast to the idea that this narrative does not become so until someone hears – or interacts – with it. The dynamic part of simulation comes from learners engaging with the narrative core model, manipulating it, and constructing their own story. From this evidence, it appears that simulation and gaming are fully within the narrative range.

INTERACTIVITY AND LUDOLOGY

The rationale behind separating narratology and ludology is at odds with the aforementioned claim, as it points out the overlap between the two, a possible "inter-paradigm debate" (Giddens, 1976, p. 142). Unintentionally, we have already described a great deal of the precepts of ludology above. We have also previously defined ludology, but the many varying definitions of ludology beg for further articulation. As stated rather frankly by Juul (2005):

As it happens with popular terms, there are many competing interpretations of it. Here are the five most popular interpretations of ludology for the time being:

- The study of game
- The study of game as rules, ignoring their fictional content
- The study of game with a strong anti-narrative stance (meaning: against blindly using traditional narratology, but including the fictional content of game).
- A group of people around the Game Studies journal (decidedly wrong – read the articles, please).
- The people at the Game Research Center in Copenhagen (also wrong – read what is actually being published). (¶ 14)

Some ludologists have argued that simulation and gaming are not narratives because their characteristics are incompatible according to current narratology definitions (Frasca, 2003b) – e.g., that "game are game and stories are stories and these types of cultural artifacts… present radically distinct essences" (Ryan, 2001, p. 6). Traditionalist narratology's foremost purpose is to achieve interactivity, though – a goal shared by ludologists; and expansionist

narratologists deconstruct and challenge narrative's structure and plot – one of ludology's most popular methods.

By the same token, narratologists have shown overlap in their work (for a sample of works using cognitive theories of learning, see Appendix A). For example, ludology embraces ideas falling squarely within the labeled category of fidelity. Fidelity has been defined as:

> The degree of similarity between the training situation and the operational situation which is simulated. It is a two dimensional measurement of this similarity in terms of (1) the physical characteristics, for example visual, spatial, kinesthetic, etc.; and (2) the functional characteristics, for example the informational, stimulus, and response options of the training situation (Hays & Singer, in Feinstein & Cannon, 2001, p. 58).

Most ludologists dismiss narratology because they believe that it cannot explain all of the phenomena associated with game; that "because game are not merely watched, they are played, they supplement this debate with the phenomenon of action… the game theorist must talk about actions, and the physical or gameworlds in which they transpire" (Galloway, 2004, ¶ 3). An analogy for the rationale that game is not narrative has been described in many ways, for instance: "If I throw a ball at you I don't expect you to drop it and wait until it starts telling stories" (Eskelinen, 2001, ¶ 1).

These opinions are beginning to shift, however. A new movement is calling for hybrid approaches (Mateas, 2002), a "middle ground" stance (Jenkins, 2003), compromises, and overlap between the two perspectives (Ryan, 2001). Some of the most avid ludologists, such as Juul and Aarseth, have stated that (1) game contain both narrative elements, sequences, and structural traits (Juul, 2001) and (2) there is significant overlap between games and narrative (Aarseth, 1997). Perhaps most striking, the expanded definitions of narrative posed by Ryan (2001) include a phenomenological category of narratives that explain how stories are constructed in simulation and games; making both paradigms viable options. This may lead one to conclude that our definitions of narrative need work – not that narratology itself is inferior.

Ryan (2001) suggests that ludology should expand to incorporate narratology; while Eskelinen (2003) hints at the opposite, stating, "a mere story is not sufficient to make something a narrative, as there must also be a narrative situation implying the presence of narrators and narrates" (¶ 1). Integrating these two polar opposites is relatively simple, and could be expressed simply: a narrative does not become so until someone interacts with it (a hermeneutical perspective). Thus, we propose the two are indivisible, equal, and necessary for the paradigmatic shift on our scientific horizon.

COMPETING PARADIGMS OR THEORIES?

In the pedagogical realm of simulation and gaming, narratology and ludology are just now beginning to surface through anomalies in the related discourse. In the non-pedagogical realm of gaming, however, anomalies have been evident for decades. Both indicate a paradigm shift found in normal scientific development (Kuhn, 1962; Lundberg & Young, 1995). Thus, within our pedagogical simulation and gaming community, we must look deeper; since it is possible that this is not a shift from old paradigm to new, but a pre-paradigmatic shift. If this is the case, narratology and ludology may merely be competing theories.

Exploring the "frame of paradigm" (Lundberg & Young, 2005, p. 45) may further inform our discussion. Friedrichs (1970) defined paradigm as "a fundamental image a discipline has of its subject matter" (p. 55); and Ritzer (1975) expands further, stating:

> A paradigm is a fundamental image of the subject matter within a science. It serves to define what should be studied, what questions should be asked, and what rules should be followed in interpreting the answers obtained. The paradigm is the broadest unit of consensus within a science and serves to differentiate one scientific community (or sub-community) from another. It subsumes, defines, and interrelates the exemplars, theories, and methods and tools that exist within it (p. 189).

How can we prove that narratology and ludology are competing paradigms, rather than competing theories? The fact is that we – at least here as two sole inquirers – cannot. As nebulous, holistic, and abstract forms, paradigms are sometimes difficult to reveal. We can, despite this deficiency, look at these groups' community structures, commitment networks, shared examples, tacit knowledge and intuition, and incommensurability (Kuhn, 1962; for a summary, see Table 1).

Kuhn's (1962) first advice, to examine community structures, is the simplest of the five. Ludology, in its relative infancy, has remained firmly within non-pedagogical game studies. Narratology, much older in nature, has been transferred from literary studies to numerous disciplines – most relevant here, that of pedagogical simulation and games.

His second advice is to explore group commitment networks, or schools of thought. The assumptions related to schools of thought ask the question, "What conceptual work and its investigators deserve allegiance?" (Lundberg & Young, 2005, p. 48). In narratology, a wide range of investigators are shown allegiance in multiple disciplines, including drama and literary studies (e.g., Jahn, 2001), education (e.g., Bruner, 1960), cognition (e.g., Schank,

Table 1: Summary of Kuhn's (1962) Characteristic Differences for Separate Paradigms

Paradigm Characteristics	Narratology	Ludology
Community structures	Mostly pedagogy, limited number of non-pedagogy researchers	Non-pedagogical game studies, although some thematic overlap with pedagogy
Group commitment networks	Wide range of disciplines, including drama & literature, education, cognition, management	Narrow range of allegiances, limited to non-pedagogy - one central research center, one peer-reviewed journal, and between one and two dozen primary investigators
Shared examples	Computer simulation, non-computer simulation, role play, experiential learning, drama, literature, film	Videogame, virtual reality, hypertext, television, and emergent forms of computer play
Tacit knowledge and intuition	Pedagogical side of experience - i.e., learning and cognition	Non-pedagogical side of experience - i.e., play
Incommensurability	Inconclusive - depends on investigator's stance regarding reductionism and holistic thinking	

1990), and management (e.g., Weick, 1995). Ludologists show allegiance to a much narrower range of investigators almost exclusively within their community (e.g., Aarseth, 1997; Eskelinen, 2003; Juul, 2001), with Frasca (1999; 2003a; 2003b) being the oft cited forefather.

Similarly, the respective subject matters and exemplars of each community show little to no overlap, and where overlap occurs, the matters are "approached from incompatible perspectives" (p. 176). Ludological subject matter centers on videogame, virtual reality, hypertext, television, and emergent forms of computer play. Narratological subject matter reflects the variety of disciplines it inhabits, including but not limited to computer simulation, non-computer simulation, role play, experiential learning, drama, literature, and film.

Subject matter and exemplars speak to the intuitions of each community. Ludology embraces the non-pedagogical side of experience – such as play – and narratology favors the pedagogical side more focused on learning and cognition. However, narratology has been overtly applied in the ludologist community, and ludological subject matter has been touched upon by narratologists (e.g., Bizzochi & Woodbury, 2003).

MORE DEBATE AND FUTURE RESEARCH

From the above, we can surmise that the two camps are not completely incommensurable, but this opens an enormous philosophical dispute between reductionism and holistic thinking. At this point, the results on narratology and ludology as paradigms or theories are inconclusive. This is of no matter to the prediction that a shift in paradigms is soon to come, though. Heated debate between two theories is a sign of anomalies just as much as that between two paradigms. The only matter left to determine is if this is a shift from old paradigm to new, or of nonexistent paradigm to the first one identified.

A pre-paradigmatic shift is "regularly marked by frequent and deep debates over legitimate methods, problems, and standards of solution, though these serve rather to define schools than to produce agreement" (Kuhn, 1962, p. 48) – exactly the present state of narratology and ludology, at least in non-pedagogical game study. This does not automatically make it a pre-paradigmatic shift, however; as the aforementioned characteristic is shared with shifts from old to new paradigms.

One way we can find if this is a pre-paradigmatic or a regular paradigmatic shift is through the presence of anomalies, because "anomaly appears only against the background provided by the paradigm" (Kuhn, 1962, p. 65). Significant narratology-versus-ludology anomalies have surfaced in non-pedagogical gaming studies, and a few have appeared in our pedagogical community of simulation research. Gaming theorists debate these topics; while we have, in the past, discussed narratological and ludological precepts with little thought of one side versus the other (for an exception, see Bizzocchi & Woodbury, 2003). This could signal that game studies will experience a pre-paradigmatic shift while we experience a paradigmatic shift or even none at all. It could also signal nothing more than temporal differences, where pedagogical studies lag behind non-pedagogical studies that are better-funded or moving at a quicker pace. Again, the results are inconclusive.

CONCLUSION

In our quest to establish sound theoretical foundations for computer simulation research, we must examine the paradigms or theories to which different camps within our related disciplines adhere. Currently, two main schools of thought prevail: narratology and ludology. Narratology tells us that people learn through taking in, reconstructing, and acting out or telling stories. Ludology tells us that people interact with reality or representational experience with or without a narrative structure. It is not yet clear whether these two schools of thought center around two respective paradigms or theories; but it is clear that anomalies continue to surface in both camps, and have remained unresolved.

Like the chicken-and-the-egg riddle, we are faced with the same question of which comes first: the story or the person who will hear and tell it? Can there be a story without a prerequisite individual? If the individual comes first, can he or she create knowledge or learn without a story to be told? Whether the debate involves theories, paradigms, or altogether different holistic constructs, narratology and ludology are practically and philosophically inseparable. Thus, fusing the two may prove to be the ideal paradigm for future computer simulation research.

We are now aware of our own evolution as a scientific community, and have the choice – the responsibility – of actively, consciously, and rigorously pursuing scientific progress. Even though the narratology versus ludology debate has nearly exhausted the non-pedagogical game community, we are just now realizing this stream of discourse exists. Learning from their past by transferring the debate to our pedagogical computer simulation community may prove to be a vital boost to our inquiries. Ignoring this rich discourse may prove to have just as much impact, and delaying our progress by another twenty five years would likely guarantee that we will never catch up.

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Appendix A: Sample of Works in Simulation with Associated Philosophical Position

Subtopic	General themes	Citations	Philosophical Position
Learner Orientation	Inability to deal with cognitive demands	Jonassen, 1989	n/a
	Designer neglect of learner support	Hawk, McLeod & Jonassen, 1985	n/a
	Roles of explicit behavioral objectives	Hannafin & Hughes, 1986	Narratology
	Specificity of activities and attention	Ho, Savenye & Haas, 1986	Narratology
	Specificity of activities and learner ability to generalize information	Krahn & Blanchaer, 1986	Narratology
	Learner disorientation	Edwards & Hardman, 1989	n/a
Lesson Presentation	Cognitive resource allocation	Gavora & Hannafin, 1995	n/a
	Multimodal presentation and multiple coding	Hsia, 1971; Severin, 1967	Ludology
	Multimodal presentation and redundancy of information	Van Mondfrans & Travers, 1964	Ludology
	Mutimodal presentation and learner performance	Yang, 1993	Ludology
	Information coding and recall	Paivio, 1979	Narratology
	Visual representations / illustrations	Perkins & Unger, 1994	Ludology
	Illustrations and content recall	Dunston, 1992	n/a
	Illustrations and content integration	Kenny, 1993	n/a
	Animation	Park & Gittleman, 1992	n/a
	Animation and support or replacement to oral presentation	Mayer & Anderson, 1992	n/a
	Animation providing coding support and feedback	Rieber, 1992	n/a
	Interaction with and manipulation of animated content	Rieber, 1990	Ludology
	Fidelity and learner performance	Alessi, 1988	Ludology
	Text placement and display	Aspillaga, 1991; Grabinger, 1993	n/a
	Metering information with windows	Benshoof & Hooper, 1993; Billingsly, 1988	n/a
	Effectiveness of color	Dwyer & Lamberski, 1982-1983	Ludology
	Distraction potential of color	Hannafin & Peck, 1988; Rieber, 1994	Ludology
Encoding Support	Stages of reaching learning meaningfulness	Mayer, 1993	Narratology
	Stimulation of deeper information processing	Wittrock, 1990	n/a
	Effectiveness of encoding support	Bliss, 1994	n/a
	Personalized instruction and memory	Miller & Kulhavy, 1991	n/a
	Personalized instruction, self-referencing, and cognitive demands	Lopez & Sullivan, 1991	n/a
	Interaction, overt responses, and differentiated lesson branching	Floyd, 1982	Ludology

	Interaction and response frequency	Bork, 1985	Ludology
	Conceptual model for human-computer interaction	Gavora & Hannafin, 1995	Ludology
Error Correction	Embedding errors in simulations	Allen, Lipson, & Fisher, 1989	n/a
	Error isolation through graphic overlay	Clancy, 1986	n/a
	Diagnostic systems for errors	Woodward & Howard, 1994	n/a
	Feedback on errors and performance	Bangert-Drowns, Kulik, Kulik, & Morgan, 1991	n/a
	Verification and elaboration in feedback on errors	Kulhavy & Stock, 1989; Priedemore & Klein, 1991	n/a
	Response certainty and feedback on errors	Litchfield, 1993	n/a
Lesson Sequencing	Learner control of sequencing	Schwier, 1992	Ludology
	Benefits and liabilities of learner control	Steinberg, 1977; 1989	Ludology
	Learner control , achievement, attitudes, & motivation	Kinzie, 1990; Kinzie & Berdel, 1990; Lepper, 1985; Pollock & Sullivan, 1990	Ludology
	Learner control, self-attribution, achievement & behavior	Kohn, 1993	Ludology
	Complete control, explicit requirements, and learner characteristics	Chun & Reigeluth, 1992	Ludology
	Adaptive control, user needs and traits	Boyd & Mitchell, 1992	Ludology
	Adaptive control and ongoing performance	Tennyson, 1984	Ludology
	Adaptive control using mathematical equations	Ross & Morrison, 1988	Ludology
	Adaptive control using computer judgment	Tennyson & Christensen, 1988	Ludology
	Adaptive control using learner judgment	Salomon, Perkins & Globerson, 1991	Ludology
	Learner passivity and hypermedia freedom	Santiago & Okey, 1992	Ludology
	Advisement and lesson execution	Hannfin, Hall, Land & Hill, 1994	n/a
	Advisement and passive learners	Lee & Lehman, 1993	n/a
	Hypermedia linking and learner access to information	Bliss & Ogborn, 1989; Horwitz & Fuerzeig, 1994; Reader & Hammond, 1994	Ludology
Motivation	Intrinsic and continuing motivation and participation	Kinzie, 1990	n/a
	Continuing motivation and external motivators	Seymour, Sullivan, Story & Mosley, 1987	n/a
	Inherent motivation of computer-based learning	Malone, 1981; Rieber, 1992	n/a
	Conceptual model for computer-based learning motivation	Keller & Suzuki, 1988	Narratology
	Taxonomy of intrinsic learner motivation and control	Malone & Lepper, 1987	n/a

Knowledge Application	Teaching approaches for problem-solving	Lambrecht, 1993	n/a
	Monitoring of problem-solving	Delclos & Harrington, 1991	n/a
	Embedding strategic questions and problem-solving	King, 1991	n/a
	Generalizability and effectiveness of strategies	Perkins & Salomon, 1989	n/a
	Computer-based cognitive tools and teaching problem-solving strategies	Kozma, 1987	n/a
	Domain-specific background and proficiency	Pea & Kurland, 1987; Perkins & Salomon, 1989	n/a
	Concept utility and context diversity	Prawat, 1991	Narratology
	Computer augmentation of problem-solving	Pea, 1992	n/a
	Computer-aided mental transformation	Kozma, 1991	n/a
	Motion sensor feedback and learner association	Brasell, 1987	Ludology
	Motion sensor feedback and learner association	Brasell, 1987	Ludology
	Interactive video and problem-solving	Atkkins & Blisset, 1992	Ludology
	"Near" and "far" transfer continuums	Clark & Voogel, 1985	n/a
	Instructional strategy's impact on transfer	Salomon & Perkins, 1989	n/a
	Computer microworlds as representing abstract, physical phenomena	Kozma, 1991; White, 1992	Narratology
	Mindful abstraction and "high-road" transfer	Salomon & Perkins, 1989	n/a
	Meaningful context, knowledge and skill	Choi & Hannafin, 1995	Narratology