# Important factors and elements of instructional design within games

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## Introduction

This document will look at different factors and elements that should be taken in consideration during instructional design for a game. By looking at how things such as cognitive load theory, narrative, player positioning and choice could be applicable to games, we might be able to find an ideal way to create instructional design for a game. The document will focus more on how the elements could be applicable to games meant for entertainment rather than games meant for educational purposes but could most likely also be applicable for that purpose.

## Cognitive Load Theory

Cognitive Load Theory (CLT) explores how the knowledge of human cognition and the interaction between information structures can be used to make instructional design more efficient. Jeroen J. G. van Merriënboer and John Sweller[1] said this about Cognitive Load Theory, "Aiding the accumulation of usable rather than random knowledge in long-term memory means that information need not be freely discovered by learners but rather be conveyed in a manner that reduces unnecessary working memory load". This quote sums up why cognitive load theory is useful in instructional design. The theory is based mostly around the relation between working memory and the long-term memory of a human being. Working memory can store a limited amount of elements for only a short period of time when exposed to novel information, but when working memory has to retrieve information from the long-term memory it seems to know no limitations[2]. This is because long-term memory contains cognitive, structured schemata that essentially combine smaller ideas into more complex ideas which are considered as one element and are not heavy for the working memory in comparison to novel elements. So when a person is dealing with a lot of new information for which there is no schemata available, the working memory will show limitations. This is because as the amount of new elements grows linearly, the amount of possible combinations grows exponentially leaving too much information to simultaneously process. The amount of connections or interactions between different elements can be classified as element interactivity. If something has a high element interactivity, it is difficult to understand and needs a schemata. Once a schemata has been formed and repeated frequently, the progress becomes an automated process and the action won't require any working memory. The working memory load may be affected by the intrinsic nature of the task (intrinsic cognitive load) and the way that the task is presented (extraneous cognitive load). There is also a third form of cognitive load which is germane cognitive load[3]. Germane cognitive load is the amount of working memory that is devoted to form schemata and automation.

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[1] Jeroen J. G. van Merriënboer, and John Sweller. (2005). Cognitive Load Theory and Complex Learning: Recent Developments and Future Directions. Educational Psychology Review, Vol. 17, No. 2

[2] Ericsson, K. A., and Kintsch, W. (1995). Long-term working memory. Psychol. Rev. 102: 211–245.

[3] Kirschner, P. A. (ed.). (2002). Cognitive load theory. Learn. Instruct. 12(special issue): 1–154

In an earlier version of CLT research[4] it stated that intrinsic cognitive load could not be altered by instruction which is why the research focused mainly on how extraneous cognitive load could be altered to reduce the load on working memory. Materials with low element interactivity don't necessarily require a decrease in extraneous cognitive load because there are sufficient cognitive resources for learning. However materials that have a high element interactivity could use the decrease in extraneous cognitive load in order to free up working memory that could potentially be devoted to learning.

But as research on the subject increases over the years it had become apparent that in some situations lowering extraneous cognitive load would not suffice and that new methods should be developed to also lower the intrinsic cognitive load. They try to achieve this by giving problem solving support.

One of the methods they tested was by giving the learner a process worksheet that provides guidelines, hints and phases the learner had to go through during problem solving[5]. But the method proved that having a process working sheet would only increase cognitive load due to the learners having to split their attention which would only increase load on working memory[6]. It was suggested and proven that in some situations studying the worksheet before performing the learning task would be a better solution since the learners could subsequently recall the schema from their long-term memory which would lighten the load on the working memory[7].

Another method they tested was by artificially reducing element interactivity in an early stage and thus isolating the elements[8]. The intrinsic cognitive load would go down since less processes had to run simultaneously. Later in the process, should the learner be exposed to the full complexity of the elements and their interactions to fully understand the material.

In other studies it also became apparent that instructional methods that would work on novice learners became neutral or negative experiences as their expertise grew, this is called the expertise reversal effect[9]. In order to prevent such an effect from happening, the instructional methods should be dependent on the learner's level of expertise. The instructional method should be assessing the learner and adapt itself to the learner's expertise but this is a difficult thing to achieve.

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[4] Sweller, J., van Merri¨enboer, J. J. G., and Paas, F. (1998). Cognitive architecture and instructional design. Educ. Psychol. Rev. 10: 251–296.

[5] Nadolski, R. J., Kirschner, P. A., and van Merri¨enboer, J. J. G. 2005. Optimizing the number of steps in learning tasks for complex skills. Br. J. Educ. Psychol.

[6] Kester, L., Kirschner, P. A., van Merri¨enboer, J. J. G., and Baumer, A. (2001). Just-in-time information presentation and the acquisition of complex cognitive skills. Comput. Hum. Behav. 17: 373–391

[7] Kester, L., Kirschner, P. A., and van Merri¨enboer, J. J. G. 2005. Just-in-time information presentation: Improving learning a complex troubleshooting skill. Contemp. Educ. Psychol.

[8] Pollock, E., Chandler, P., and Sweller, J. (2002). Assimilating complex information. Learn. Instruct. 12: 61–86.

[9] Kalyuga, S., Ayres, P., Chandler, P., and Sweller, J. (2003). The expertise reversal effect.
Educ. Psychol. 38: 23–31.

The effect of variability in materials was also tested and seemed to contradict cognitive load theory. High variability seemed to increase cognitive load rather than reducing it but would help significantly in the creation of schemata[10]. So the use of variability could be beneficial for the overall learning process. If the instructional designer lowers the amount of extraneous cognitive load, it could potentially be replaced by germane cognitive load. Unfortunately it is often the case that learners cannot fully devote their processing resources to learning. Studies[11],[12] had proven that preparing the learners before the test would improve the example elaboration.

**Game design and Engaged learning**

Game designers incorporate a number of strategies and tactics in order to get players engaged into playing their game. Looking at which of these methods could potentially be used in the creation of instructional design could prove beneficial. Bowman's[13], Malone's[14] and Provenzo's[15] research looks at why games are so engaging. All of them noted the presence of elements such as a clear goal in the game, increasing difficulty, immediate feedback, low or no punishment for risk taking and the importance of choice. All of these elements according to Jones et al.[16] and Schlechty[17] are part of engaged learning. Even though video games and engaged learning have so much in common there is something about games that motivates people into engagement.

Michele D. Dickey[18] suggests that the player positioning within the learning environment plays a role. Even though it might hold little relevance to the design of some educational material it does influence the engagement of the user. For example, the shift from a orthographic view to a first-person view resulted in moving the player from outside the game space into becoming a part of the games pace which made the experience more engaging[19].

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[10] McKeough, A., Marini, A., and Lupart, J. L. (eds.). (1995). Teaching for Transfer: Fostering Generalization in Learning. Hillsdale, NJ: Erlbaum.

[11] Renkl, A., and Atkinson, R. K. (2001, August). The effects of gradually increasing problemsolving demands in cognitive skill acquisition. Paper presented at the 9th Conference of the European Association for Research on Learning and Instruction (EARLI), Fribourg, Switzerland.

[12] Stark, R., Mandl, H., Gruber, H., and Renkl, A. (2002). Conditions and effects of example elaboration. Learn. Instruct.

[13] Bowman, R. F. (1982). A "Pac-Man" theory of motivation: Tactile implications for classroom instruction. Educational Technology, 22(9), 14–17.

[14] Malone, T. W. (1981a). Toward a theory of intrinsically motivating instruction. Cognitive Science, 4, (333– 369).

[15] Provenzo, E. F. (1991). Video kids: Making sense of nintendo. Cambridge, MA: Harvard University Press.

[16] Jones, B., Valdez, G., Norakowski, J., & Rasmussen, C. (1994). Designing learning and technology for educational reform. North Central Regional Educational Laboratory. [Online].
Available at: http://www.ncrtec.org/capacity/profile/profwww.htm

[17] Schlechty, P. C. (1997). Inventing better schools: An action plan for educational reform. San Francisco, CA: Jossey-Bass.

[18] Michele D. Dickey. (2005). Engaging By Design: How Engagement Strategies in Popular Computer and Video Games Can Inform Instructional Design. Educational Technology Research and Development. 53 (2) 67-83. Association for Educational Communications & Technology.

[19] Riddle, J. (2002). Cameras and Point-of-view in the gamespace. In SIGGRAPH2002 Proceedings, ACM, 155. San Antonio, TX.

Michele D. Dickey (2005) also suggests that it would be beneficial to integrate narrative in instructional design for it provides opportunities for reflection, evaluation, illustration, exemplification and inquiry[20,21]. Besides narrative would be positively influencing comprehension[22]. By mixing gameplay with narrative, game designers are able to enhance the engagement of the players.

One of the before mentioned elements of engaged learning is the importance of choice. Choice is an important element for the engagement of the player. So by giving the player of a game choices that relate to gameplay should increase the amount of engagement. These choices should make the user analyze diverse sources of information in order to form and evaluate a strategy. For the design of sophisticated game environments it is required that players must think more extensively about their choices in order to interact properly.

**Conclusion**

In this document we have looked at several factors and elements that should be taken in consideration during instructional design. We have seen that cognitive load theory could be used to construct methods that conduct information to the player more efficiently. As research progresses on this subject it could hold new methods and tools that could help make instructional design more efficient in the future. We also compared game design and engaged learning and looked at how some game elements would prove to be beneficial for player engagement such as implementation of narrative and choice. Still, the information provided in this document only touches a small part of the elements and factors that should be taken in consideration during instructional design in games and more research should be done.

[20] Conle, C. (2003). An anatomy of narrative curricula. Educational Researcher, 32(3), 3–15.

[21] Eisner, E. W. (1998). The enlightened eye: Qualitative iinquiry and the enhancement of educational practice. New Jersey: Prentice Hall.

[22] Laurillard, D. (1998). Multimedia and the learner's experience of narrative. Computers in Education, 31, 229–243.

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