Comp 341/441 - HCI

Spring Semester 2020 - Week 7

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Cognitive Load

forced, unnecessary thinking

- our goal is not to reduce thinking relative to our application
  - *intellectual thinking different from forced, unnecessary thinking due to poor design...*
- our app should promote and facilitate thinking, and record results where applicable
- our app should try to limit extraneous cognitive load for activities such as
  - *active research activities*
  - *creative development and output*
  - *general problem solving and issue resolution*
  - *reading, note taking, and other general tasks...*
- cognitive load reduced by an app's focus upon
  - *the task in hand, relevancy of UI information and implementation, reduction in extraneous content...*
- reduce interface induced thinking additional to the primary task
  - *better contextual support and research*

Image - Cognitive Load

distraction free

Kindle Paperwhite

Source - Amazon Kindle Paperwhite

Image - Cognitive Load

app's *Big Green Button*

Xerox's Big Green Button

Source - Fuji Xerox Printers

Video

Fitts’s Law - Part 1

Mouse Pointers & Fitts’s Law - UP TO 4:14
Source - Mouse Pointers & Fitts’s Law - Computerphile - YouTube

Cognitive Load

quantify cognitive load

- interested in how we can quantify the cognitive load
  - *required by a user for performing a given task*
- better understanding of load issues within our application and interface
  - *helps guide us in apportioning emphasis and control in design*
- for a particular task we can compile a list of actions, steps…
  - *estimate a score (% etc) which represents our understanding of required effort*
  - *total all of the action scores to assign an overall score for the effort required*
  - *evaluate different design options by comparing overall scores…*
- KLM-GOMS model
  - ***Keystroke-Level Model for the Goals, Operators, Methods, and Selection Rules***
  - *Card et al. "The Psychology of Human-Computer Interaction." 1983.*

KLM-GOMS Model

intro

- users divide goals into a series of tasks
  - *each task requiring some initial thought and preparation*
- preparation known as **task acquisition time**
  - *can be very short for simple, routine tasks*
  - *may be much longer, perhaps a few minutes, for more creative, original tasks*
- user will then continue with their chosen task
  - *using a sequence of actions or operations*
- total required time to complete the actions is known as **task execution time**
- total time required to complete task is the sum of
  - *task acquisition time + task execution time*
- modified models for mobile devices, such as phones…
  - *eg: Keystroke-level model for advanced mobile phone interaction*

KLM-GOMS Model

usage

Code	Operation	Time (in seconds)
K	Key press & release (keyboard)	Best Typist (135 wpm) = 0.08
		Good Typist (90 wpm) = 0.12
		Avg. Skilled Typist (55 wpm) = 0.20
		Poor Typist (40 wpm) = 0.28
		Typing Random Letters = 0.50
		Typing Complex Codes = 0.75
		Worst Typist = 1.20
P	Point mouse to an object on screen	1.10
B	Button press or release (mouse)	0.10
H	Hand from keyboard to mouse & vice-versa	0.40
M	Mental preparation (operation)	1.20
T(n)	Type string of characters	n x K seconds

wpm = words per minute

Source: Kieras, D. 1993. Wikipedia

example

Example implementation - text search including mental operators

Action	KLM-GOMS Code	Time (in seconds)
move mouse to **search** menu	H (hand to mouse)	0.40
	M + P (search menu)	1.20 + 1.10
select **search** menu...	BB (select search menu)	2 * 0.10
click on *find text* link...	M + P (find text menu item)	1.20 + 1.10
	BB (select menu item)	2 * 0.10
	H (hand from mouse to keyboard)	0.40
enter search term *et*	KK (type *et* characters)	2 * 0.20 (avg. typist)
click the *OK* button	H (hand from keyboard to mouse)	0.40
	M + P (*OK* button)	1.20 + 1.10
	BB (click button)	2 * 0.10
Total		9.10

BB = double button press to simulate mouse click and release (0.20 seconds)

Video

Fitts’s Law - Part 2

Mouse Pointers & Fitts’s Law - UP TO 7:27
Source - Mouse Pointers & Fitts’s Law - Computerphile - YouTube

Reducing Cognitive Load

a few tips and tricks...

- consistent use of icons, labels, names, and general visual presentation
  - *consistency should include design for multiple tasks as well*
- clear navigation for process steps...wizards, paged results etc
- include visual cues and clues...saves users having to remember functionality
- avoid popups except for explicit intervention reasons...warnings, errors etc
- avoid redundancy in content and rendering
- relational material should be organised in close proximity to one another
- identify and remove unnecessary steps
- automate processes, steps where possible
- reduce delays and latency as much as possible...use progress updates, bars
- option for templates, tutorials for new documents in productivity apps etc
- video and audio tutorials often easier to follow and understand than text only
- repetitive user data entry can be avoided
  - *app should not force a user to continually remember such data and information*

flow

Concept of **Flow** by **Mihaly Csikszentmihalyi**

- user's creativity and productivity are high
  - *performance of activity occurs naturally and unconsciously*
- user experiences deep concentration and immersion in their current activity
  - *user is effectively both alert and relatively relaxed*
- living in the moment
  - *sensation of being so engrossed in an activity a user is unaware of the passage of time*
- balancing interest and challenge
- user is confident and exhibits a sense of control over their current situation
- user is working progressively towards achieving a specific goal
  - *eg: in games this might be as simple as getting to the next level*

TED 2004 - Flow, the secret to happiness

Video - Concept of Flow

working memory and the concept of flow

TED 2013 - Peter Doolittle: How your “working memory” makes sense of the world

Reducing Cognitive Load

flow states and software

- unusual for beginners to be able to gain a sense of **flow**
  - *normally requires some level of comfort or familiarity*
  - *ease with the general operation and control of the application*
- acquiring a state of **flow** is quite difficult
  - *focused concentration is often not enough*
  - *reducing cognitive load in apps can aid in the process*
- interruptions in the real world can break a user's sense of **flow**
  - *visual clutter and noise in interfaces can have the same effect*
  - *interface distractions can also break a user's sense of **flow***

Reducing Cognitive Load

interface suggestions for flow

- reduce interruptions in the interface unless intentional for warnings, errors…
  - *non-important modal popups, notifications should be avoided*
- keep visual presentation simple
  - *bright, loud colours and images are jarring to the user's eye*
  - *unnecessary, prolonged or repetitive animations are distracting*
- sequential navigation should be obvious
  - *do not require the user to search the interface for **next**…*
- avoid switching between tabs, windows, pages for related information
- saving a document, work etc should be easy and intuitive for a user
- output and display progress reports for ongoing activities
  - *progress bars, spinning wheels, timers…*
- offer feedback in a prompt and consistent manner within the interface
- multi-tasking for users is difficult
  - *don't ask your users to perform too many interface tasks at once…*

Incentives, offers, and games

motivating our users

- consider motivation, persuasion, or helpful *nudging* in our designs
- design our interfaces to encourage and help increase productivity
- particularly useful for certain types of applications and sectors
  - *user participation apps*
  - *productivity tools*
  - *community related apps*
- compare this type of application to gaming
  - *often adept at engaging and keeping a user's attention*
- consider how and where games are compelling and addictive
  - *adapt applicable concepts for our own design*

Incentives, offers, and games

compelling and addictive nature of gaming

- current trend in design to apply addictive qualities of gaming to application design
  - *known as **gamification***
- most games have some goals and rewards, which encourage and incentivise a user
  - *often a built-in incentive to reach the next level, a sense of satisfaction*
- games may include elaborate systems of player rankings
  - *rankings act as system of validation, offers easily quantified feedback to users*
- multiplayer games offer an element of direct competition
  - *user's sense of skills, standing, and validation enhanced by opportunity to compete and win*
  - ***high scores** on a leaderboard help this sense of competition*
- multiplayer games also offer sense of **social** connection and community
  - *head-to-head gaming, group playing, or simply ability to share, compare, discuss...*
- online role-plaing games a good example of social awareness and collaboration

Video

Gamification

Gamification - UP TO 3:57
Source - Gamification - Extra Credits - YouTube

Incentives, offers, and games

examples of gamification

1. Good examples of the use of gamification within social context

   Source - Yu-Kai Chou & Gamification

2. Khan Academy Knowledge Map

   Source - Khan Academy

3. Play to Learn with Khan Academy

   Source - GCO

4. Scratch Programming Language

   Source - MIT

changing the brain game

> *"The immense amount of time spent with games during a child's formative years has led them to be literally 'hardwired' in a different way than those who came before"*

Carstens, A., and Beck, J. 2005. "Get ready for the gamer generation." Tech Trends 49. PP.22-25.

> *"Immense changes in technology over the past thirty years, of which video games are a major part, have dramatically and discontinuously changed the way those people raised in this time period think, learn, and process information…The change has been so enormous that today's younger people have, in their intellectual style and preferences, very different minds from their parents and, in fact, all preceding generations"*

Prensky, M. 2001. "Digital game-based learning." McGraw-Hill. P.17.

changing the brain game

Prensky (2001) recommends,

- fast-paced to exploit ‘twitch speed’ information processing capabilities
- emphasis on high player control and multiple tracks
  - *leverage greater multitasking abilities*
- actively engage participants
  - *highly visual environments*
  - *encourage learning by exploration*

what are simulations?

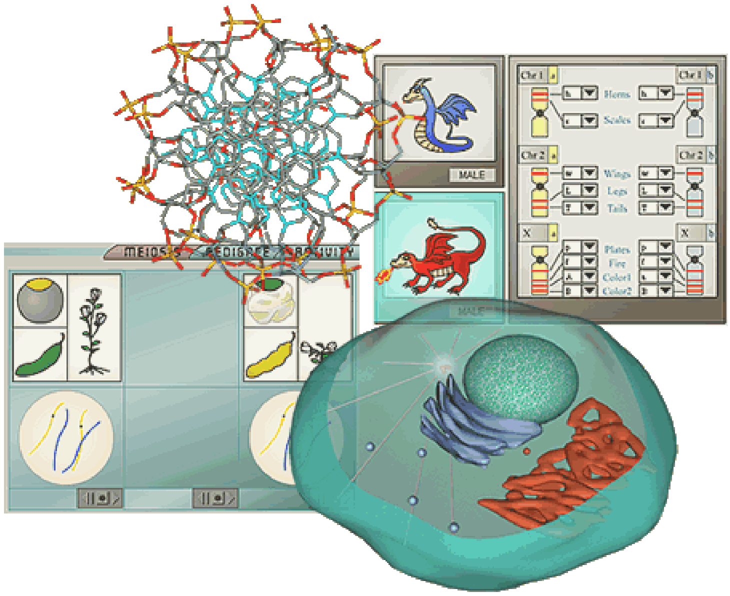
- linear interactive tutorial versus a simulation
- model of a real world system
  - *respond in dynamic and rule-based ways to user responses*
- two basic types of simulation
  - *operational and conceptual*
- operational primarily used to teach procedural skills
- conceptual simulations

Games and Simulations

what are games?

- games include a broad array of formats and features
- common elements such as
  - *competitive activity with a challenge and goal*
  - *set of rules and constraints*
  - *specific context*

Image - Dragons and Genetics 1



Games and learning with dragons

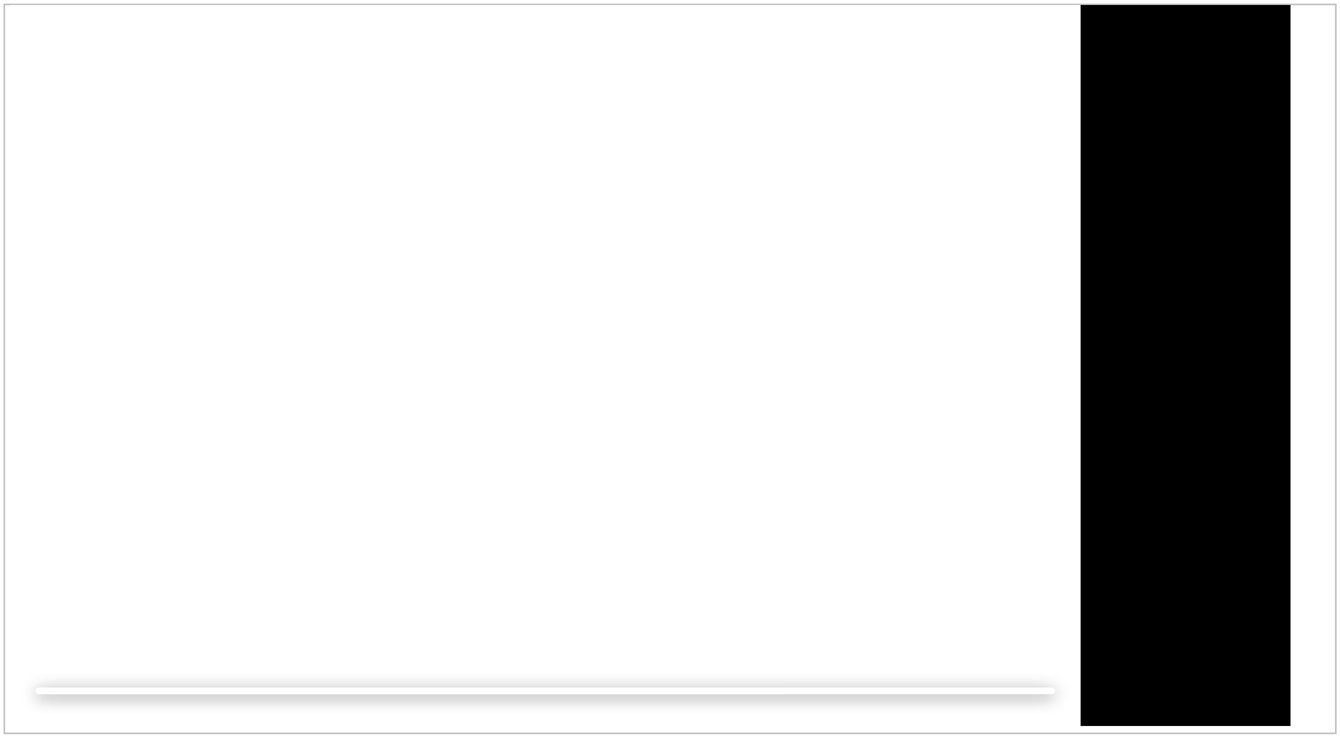
- BioLogica - Legacy

Image - Dragons and Genetics 2

Games and learning with dragons 2

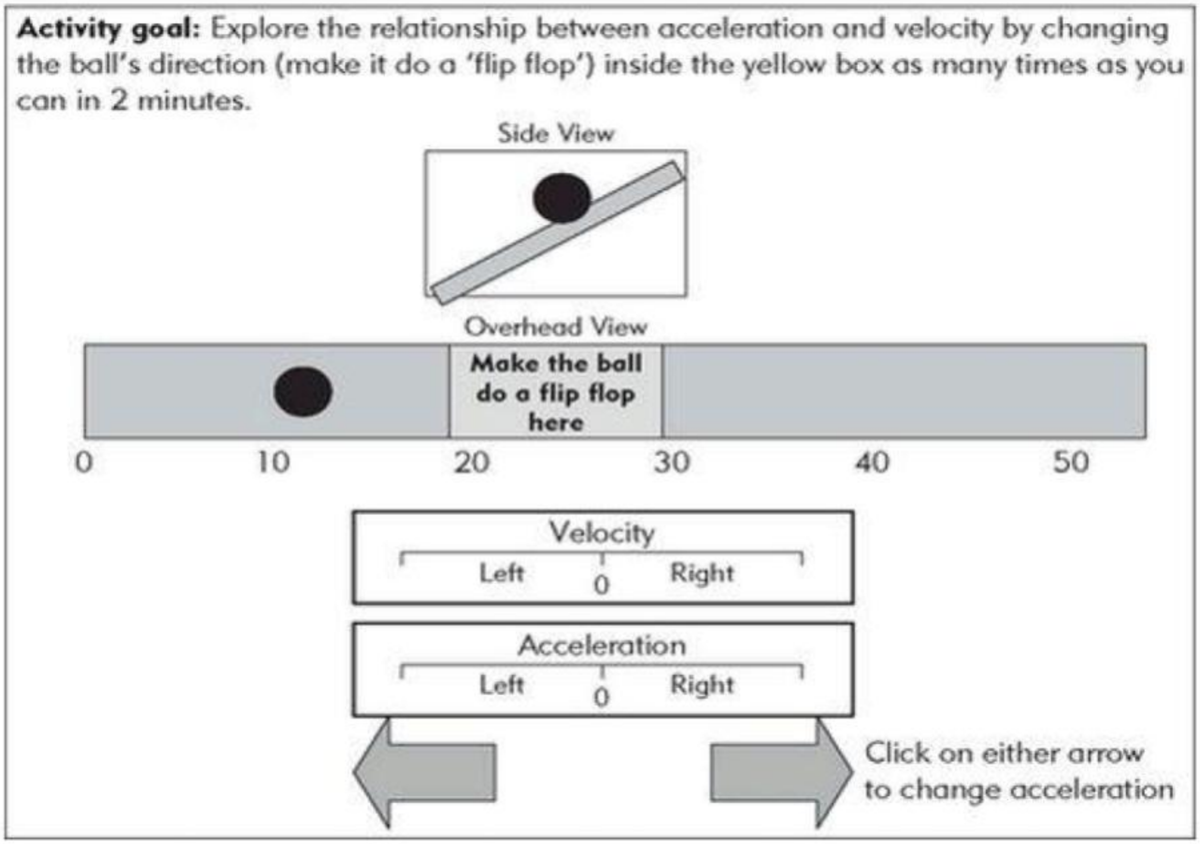
- BioLogica - Current

Video - Dragons and Genetics 3



- Geniverse - Explore heredity and genetics by breeding and studying virtual dragons

Image - Games, Teaching, Abstraction…



Games - flip flop

- Rieber, L.P. 2005. "Multimedia learning in games, simulations, and microworlds." The Cambridge handbook of multimedia learning. Cambridge University Press.
  - *Hays, R.T. 2005. "The effectiveness of instructional games: A literature review and discussion." Technical Report 2005-004. Washington.*

Games and Simulations

match game to learning goal

- Strategy, Family, Role Play, Adventure, Other…
  - *Entertainment Software Association*
- effective games and simulations for e-Learning should align features, goals…with desired instructional outcome
- Oregon Trail games appropriated by children
- Physics game counter-productive to the given physics principles
- is this inherently a bad thing?
  - *from a learning perspective - Yes*
  - *gaming perspective - No*
- transference not a bad thing…
- playtesting helps resolve many issues…
  - *shift in focus from developer and designer to players*

match game to learning goal

> *"Jeopardy-style games, a staple of games in the classroom, are likely to be best for promoting the learning of verbal information (facts, labels, and propositions) and concrete concepts. Arcade-style games…" (P.22)*

Van Eck, R.N. 2006. "Digital game-based learning." Educause Review 41. PP.17-30.

Games and Simulations

learning and game characteristics - guidance

- simulations and games that offer structure and sound learning support
- instructional explanations
- consideration and reflection on instructional content
- manage complexity
- offer instructional support

Games and Simulations

learning and game characteristics - explanations

- provide explanatory feedback instead of corrective only feedback
- try to provide brief instructional explanations between breaks in a simulation
- explanations, feedback available throughout games
  - *may be explicit guidance and examples*
  - *or subtle in its usage and intent*
- there to help the player learn about the game
  - *its gameplay, mechanics, goals...*
- guidance or nudging there to help reinforce game concepts
- when using a game or simulation lacking explanations or hints
  - *players and learners alike try to achieve the goals of the game*
  - *and learn at the same time*
  - *both activities may lead to mental overload*
- normally the game, and not the learning, that takes precedence
  - *may use this concept in our designs as well*
  - *design increasingly complex and challenging tests within a game*
- also need to be careful to encourage and help a user to reach this point
- we may consider this a way of progressing from
  - *easy to learn to difficult to master*
  - *a simple hook for the game itself*

consideration and reflection

- achieving game goals or mastery of a simulation may preclude reflection
- reflection needed to abstract lessons and learning from a game or simulation

> *“The experiential nature of an educational simulation is very compelling - users often become very active and engaged in a simulation, similar to the experience of playing a video game. However, the intense and demanding interactivity of many simulations may not provide adequate time for the user to carefully reflect on the principles being modeled by the simulation”*

Rieber, L.P., Tzeng, S.C., and Tribble, K. 2004. “Discovery learning, representation, and explanation within a computer-based simulation: Finding the right mix.” Learning and Instruction 14. PP.307-323.

Games and Simulations

complexity in games

- ways to manage mental load in games
  - *manage complexity of the simulation or goal of the game*
  - *optimise the complexity of the interface*
  - *provide instructional support such as memory aids or activity guidance*
- general concept of progression within most games
  - *from text-based games to platformers, role-playing, racing simulators…*
  - *each provides the gamer with an opportunity to learn and progress*
- management of mental overload becomes a part of the game
  - *player learns, adapts, and improves within a game*
  - *game may progress without causing mental overload to the player*
- mental overload will simply cause the player
  - *to restart the game (or abandon in some cases)*
  - *learn and adapt*
  - *then oncemore try to progress*

Games and Simulations

managing complexity (goal progression)

- start with a relatively easy task or goal
- move gradually to more complex environments
- consider options to allow a player to manage their level of complexity
- consider learner, and gamer, experience levels
- dynamically adapt game complexity based on accuracy of responses

Games and Simulations

managing complexity - training wheels

- "training wheels" principle for software simulations
  - *Carroll, J.M. 2000. "Making use: Scenario-based design of human-computer interactions." MIT Press.*
- learners and players alike work with a simulation where only some of the functionality is enabled
- full interface may be visible
  - *only relevant elements of it work*
  - *players can't go too astray during early trials and tests*
- as more tasks are learnt and acquired
  - *functionality constraints are gradually released*
  - *until the player is working with a highly functional system*
- as the player gains experience, greater functionality is added

Games and Simulations

managing complexity - faded worked examples

- another option is to use faded worked examples
  - *might begin with a complete demonstration of the task*
  - *then, players view a demonstration of the first few steps of the task*
  - *and, finish it on their own*
- the player assumes more and more task responsibility
  - *until they are doing it on their own*
  - *all options become available…*
- a game or simulation may incorporate such a fading strategy
  - *a player can observe a successful game segment or level,*
  - *view accompanying explanatory commentary…*
- for example, use of a computer generated agent
  - *may demonstrate how to play the game or interact with the simulation*
  - *then, the agent completes some of the steps, assigning others to the player*
  - *players assume greater control*
  - *until they're able to complete all steps or actions alone*

Games and Simulations

managing complexity - control of pace

- pacing of game or simulation
  - *Mayer, R.E., and Jackson, J. 2005. "The case for coherence in scientific explanations: Quantitative details can hurt qualitative understanding." Journal of Experimental Psychology: Applied 11. PP. 13-18.*
- control of pace within a game or simulation
  - *also important to the potential outcomes*
- fast-paced games are likely to lead to greater overload
  - *fewer opportunities for reflection*
- may sound counter-intuitive for general game design…
  - *but it manifests itself in many different concepts*
- by pace, we may refer to different concepts, e.g.
  - *rate of introduction of gameplay concepts*
    - such as options, difficulty of tasks, rewards…
  - *the perceived actual pace of a game*
    - often defined by game genre, player expectations, story…
- consider how different games handle pace
  - *varying impacts on general gameplay*
  - *rate of adoption of a given title*
  - *longevity of gaming…*
- how we manipulate and use pace in our games
  - *may affect a player's rate of learning*
  - *their enjoyment of the game*

Resources

- Card, S.K., Moran, T.P. and Newell, A. *The psychology of human-computer interaction*. Lawrence Erlbaum Associates. 1983.
- Holleis, P. et al. *Keystroke-level model for advanced mobile phone interaction.* CHI' 07. New York, USA. 2007.
- Kieras, D. *Using the Keystroke-Level Model to Estimate Execution Times.* 1993. http://courses.wccnet.edu/~jwithrow/docs/klm.pdf
- Krug, S. *Don't make me think, revisited: A common sense approach to web usability.* 3rd Edition. New Riders. 2014.
- Norman, D. *The Design of Everyday Things.* Basic Books. 2013.