Enabling Learning by Teaching: Intuitive Composing of E-Learning Modules

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Abstract

In an effort to foster learning by teaching, we propose the development of a canvas system that makes composing e-learning modules intuitive. We try to empower and liberate non-technical module users by lowering the bar for turning them into module authors, a bar previously set far too high. In turn, this stimulates learning through teaching. By making a damn fine piece of software, we furthermore make module authoring more pleasant for experienced authors as well. We propose a system that initially enables users to easily compose H5P modules. These modules are successively easy to share and modify. Through gamification we encourage authors to share their work, and to improve the works of others.

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1. Introduction

The "Bottom Of the Pyramid" (BOP) is a term central to the development of value-chains in emerging markets in developing countries. It is understood as the largest, although poorest segment of the population. The key to economic development lies in activating this segment of the population, enabling them not only to use modern (digital) services, but to author them as well[1].

The inspiration for our idea comes from applying this general framework to the field of education software. The economics of educational services are unfavourable to those who need it the most.

We improve the status quo by offering a novel system for composing e-learning modules that is easy to use by non-technical users, but expressive enough to benefit power users as well. This improvement is a stepping stone towards turning e-learning authoring into an activity achievable by even school children. It is also a stepping stone towards stimulating learning by teaching, a stimuli school children find themselves largely deprived of in most situated learning environments, i.e. schools.

2. The problem

Alas, most software is written for a small subset of the population. H5P\textsuperscript{1} is one of many novel examples of software providing added-value to tech-savvy teachers and educational software developers. However, the BOP would in this case be the students.

By providing the correct tooling and educational framework, we could enable students to act not only as users of off-the-shelf educational software, but also as authors of their own or their co-students’ learning experience. By doing so, we could allow the student to feel some degree of pride in the coursework. Moreover, it would allow for reinforced learning, as well as viral effects (sharing), a major force in the modern network economy.

Such a framework would also encourage the students to make services and tools more adapted to their particular learning situation, improving the overall user experience. It would additionally be a valuable source of inspiration for educational software developers and user experience designers. And if successful, usage data would be interesting for analytics research.

Sadly, such a framework doesn’t exist. So we want to move H5P closer to being one. In order to achieve this we provide intuitive composition of H5P modules, and, ultimately, of all kinds of e-learning modules, including new ones.

3. Our idea

We suggest developing an engaging “canvas” for authoring e-learning modules, taking cues from RPGツクール\textsuperscript{2}, Game Maker\textsuperscript{3}, and other similar software that succeed in take advantage of an intuitive interface with a capacious feature-set.

By “canvas” (or “scene graph”), we mean an easy-to-learn system of widgets and composite stores (with rich content), and flows connecting them together to a cohesive system. The widgets would initially be H5P modules.

An example of such a system might be a test leveraging media like GNU Mediagoblin, Youtube, NRK, Twitter, and Nasjonal Digital Læringsarena\textsuperscript{4} to showcase the issue at hand by embedding video and articles, etc., before testing the user’s comprehension at the end with an H5P quiz. Such a system is shown in Figure 1. Thus, the student-come-software-developer is able to prove their comprehension of multimedia (as mandated by the curriculum), and other students are permitted to take part in the learning experience. Incentives for doing so might be given by the teacher, or by arranging collaborations that invite the students to share their best ideas.

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\item\footnotemark[1] http://h5p.org/
\item\footnotemark[2] http://www.rpgmakerweb.com/
\item\footnotemark[3] https://www.yoyogames.com/studio
\item\footnotemark[4] http://ndla.no/
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Taking cue from Minecraft, we also propose another viable incentive: The student is provided with ready-made canvases with actors and stores made by other users, and encouraged to make the application perform certain actions (“gamification”). This is akin to the redstone system found in Minecraft, where even young users are able to construct discrete logic circuits providing useful functionality like opening doors, or switching on lights[2].

Consequently, we have customisable flows between widgets. They may be customised initially via simple if-expressions on the form if $\chi$ then $\alpha$, else $\beta$, where e.g. $\chi = 80\%$ completion rate, and $\alpha$ = an H5P memory game, and $\beta$ = an H5P quiz. An example of the conditions dialogue is shown in Figure 2.

Through use of our canvas, we eliminate the BOP by liberating and empowering it to make its own user experience. As an added bonus, our canvas may spark some latent creative souls, or inspire technological awareness and interest. In our increasingly computerised society, this is in itself a noble cause.

Thus, this canvas might prove to be a force for bridging the gap between just being a computer user, and having a promising future career in computer software. While Computing At School\(^5\) have had great success in the UK, there is as of today no readily-available path for acquiring the advanced knowledge needed to develop modern systems given the current education system in Norway. Grassroots organisations such as Lær Kidsa Koding\(^6\) are doing good work, but have yet to strongly influence the education system. If our canvas is picked up by prominent e-learning providers like Nasjonal digital læringsarena we can liberate and empower users through direct action, circumventing bureaucracy.

In addition to users teaching themselves technology, they also teach themselves the curriculum more effectively. The student becomes the teacher, and we achieve learning by teaching, an often sought-after method of reinforced learning. By only being e-learning module users, students are limited to learning through observation, experimentation, and (to some extent) mistakes. Learning through teaching offers advantages not possible to fully realise through either of these; advantages that won’t manifest if the student is exclusively relying on an external teacher[3].

\(^5\)http://www.computingatschool.org.uk/
\(^6\)http://www.kidsakoder.no/
BOP, we make sharing of works very simple, and make it equally simple to author derivatives (forks) and meta-works (collections). Incentive for sharing your work, and improving or remixing the work of others is provided through gamification of the canvas. As an example, there may be a reward system for users whose modules are often remixed, and for users who make an improvement to a module that then gets integrated back into the original module itself. These rewards are then presented in a positive and motivating way to the user, as shown in Figure 3.

Figure 3: A reward for positive behaviour

With gamification, we can also help ensure high quality modules. With a rating system and achievements for obtaining a high rating, we realise a self-regulating community.

Initially we aim to support authoring H5P modules, focusing our development at H5P integration. But with a good modular design we can extend our canvas to support other standards as well in the future. We also want to support embedding of things like videos and news articles. Lastly, careful attention must be paid to the application programming interface, so that it is easy for future e-learning modules to support our system.

4. The Details

4.1. Concept

We propose a canvas system wherein the user may drag e-learning modules from a toolbox, and drop them onto the canvas, as in Figure 4. The modules may be empty or finished. If they are empty, then the authoring tool for said module opens. If it is not empty, then the user may further edit it if they wish. In addition to drag-and-drop, the user may also use an “add” button, as drag-and-drop is not viable for universal design.

Figure 4: A user dragging a module onto the canvas to add it

To schedule data and control flow, the user drags arrows between the modules on the canvas. These associations may be customised. “If the user finished [module a] with a score of more than 80% correct, then direct them to [module b]; if the user did not, then direct them to [module c]”. A simple illustration of this is in Figure 5.

Figure 5: Visualised control flow

Compositions are modules themselves.

When a user wants to compose modules, users may search for which modules to use. We want to encourage reuse and remixing rather than novelties. Consequently we focus the search option before the “author new module” option. The search option is shown in Figure 6, which also shows results filtering in action.
As another incentive, when a user authors a new module, we track reuses and remixes. Users may in a presentation of all their authored modules see how many reuses and remixes have occurred, and follow links to these. If they like a remix they may merge the changes between the remix and the original.

Compositions may be derived in whole, and further developed by another author. Users may merge modifications to these as well. Consider an English Language test for a school curriculum. A teacher at a different school (or the same school next year) may want to reuse this test since they have the same curriculum. But they might furthermore want to modify it. If the original author finds these modifications useful, then it may merge them to the original.

Avatars have been successfully used before to motivate children[4]. We propose the use of an avatar for explaining the interface and pointing out problems with the compositions, such as integrity issues, e.g. “the composition never ends”, or continuity warnings, e.g. “this module is visited two times”. The avatar’s appearance may be customised. We show an example of an avatar dialogue in Figure 7, although the avatar itself is merely a placeholder.

For our actual avatars, we have chosen otters. plaimi’s mascot is an otter, so this decision is done partly for cohesive branding concerns, but primarily for the same reasons it was chosen as plaimi’s mascot in the first place: the otter is a noted playful and social creature[5]. It is furthermore considered cute by the general population, but capable of being ferocious[6], which is appealing for the target demographic as girls tend to prefer cute avatars, whilst boys prefer rude avatars[7].

To encourage certain behaviour, the avatar may reward positive behaviour with a badge, e.g. “200 remixes!”, or “remixed 200 modules!”.

Punishing bad behaviour rarely works, and punishment is easily evaded. Instead we simply prohibit bad behaviour. Chatting is done via the avatars. To communicate with another user, you visit their profile and click on their avatar to bring up a dial menu for constructing a query like “you should add [module] to your composition!” or “I like this module!”. This makes localisation much easier since these set sentences may be translated accurately. It also makes our system safe for children[8]. This is a recent trend in computer games such as Journey and Hearthstone for the same reasons. This eliminates hate speech[9], which is not acceptable with a child audience.

Users may, via their avatars as just described, encourage other users by telling them that they like their modules. There is no way to dislike a module, as that might be demotivating for children. Avatars as well as modules may be favoured. The user’s favourite modules and avatars are more easily accessible than the rest.

Users sign up with a log-on ID and password, and optionally an email address for recovering forgotten passwords. The users name
their avatars which is then their screen names. The avatar has a name. There may be duplicate names. People have duplicate names in real life too [citation needed], and society hasn’t collapsed yet. When choosing a name, feedback is given if the name is not unique.

4.2. Requirements

We place high usability requirements on our canvas system in order to enable school children to use it.

Our target demographic at its largest is pretty much everyone that wants to learn or teach something. Therefore universal design is of the utmost importance. It is furthermore legally required in Norway [10]. More importantly it is The Right Thing to do. Universal design is difficult with such a graphical system, but of the utmost importance. Compromises shall err on the side of caution and favour universal design to expressiveness.

Dealing with children has interface design implications. Tap actions should allow some slack with bigger hit boxes than actual buttons and similar measurements. Splash screens are bad, mkay. Turns out kids don’t have that great an attention-span. So get to the point quick as. These things are discussed in more detail in Section 5.

In order to encourage reuse and remixing, modules and assets are distributed under a free licence, CC-BY-SA. This also sets a positive example for school children to become good citizens of our society. Indeed so does the entire project by being licensed as AGPL[11].

4.3. Functional Details

4.3.1 Frontend

For our canvas system and frontend in general we primarily use the Elm programming language[12].

Elm is an immature language with several known shortcomings[13], but the more popular alternative JavaScript is a mature language with even more known shortcomings[14]. Although early research suggests that using Elm will not magically result in a better product[15], it does allow for purely functional programming of denotational graphical interfaces[12], which has several known advantages for interactive graphical programs[16]. Elm itself has several specific advantages as well — and excellent tooling to boot[17].

Being an immature language, not all libraries we could possibly wish for are readily available. Therefore accessing JavaScript directly is still useful at times. Thankfully, Elm comes with a sophisticated JavaScript foreign functional interface[18]. And if it becomes necessary to use JavaScript libraries to interact with JavaScript primitives presently outside of Elm’s reach, we may fall-back on JavaScript for this.

4.3.2 Backend

For dealing with all things backend we use the Haskell programming language[19]. Haskell is a mature and widely used programming language with advantages similar to that of Elm, except more advantages and more powerful advantages. Interesting advantages over Elm include laziness for modularisation[20], typeclasses for elegant ad-hoc polymorphism[21], and an in general more powerful and interesting type system[22]. Lastly, Haskell seriously equips you for all cost-models of parallelism and concurrency[23].

We write property laws and test these using QuickCheck[24], a well-established tool used in industry[25].

Haskell, being a mature language, provides us with several useful libraries to ensure a shorter time to market.

4.3.3 Reuse and remix

We want to encourage reusing and remixing. We define reuse to be using someone else’s module as-is, and remix to be using someone else’s module with modifications.

Care must be taken not to merely give incentives for having your modules reused and remixed by others, as this fosters a culture where being the author of novelties is the most rewarding. Rewards should therefore be doled out more
handsomely for actually reusing and remixing than for authoring modules that are successfully subsequently reused and remixed. This also makes sense since the latter is accumulatively (having your module be reused and remixed is tracked and awarded recursively) rewarding passive behaviour, whilst the former rewards active behaviour.

4.4. Design document

Given our emphasis on usability, we have had a design document authored by a user experience developer. This document includes a graphical profile, some specific user-interface design, and some overarching design principles. It may be found in its entirety in Appendix A.

5. First principles

We wish to discuss learning itself, and how this knowledge affects our system. A common technique used in most of these systems is spaced repetition combined with testing, i.e. the pacing of repetition throughout time. This approach is well-proven by research, and could be implemented both as a part of our services (allowing module authors to apply it to their own students), or as a part of the experience of learning the tools. An example might be: ‘After 5 days, please repeat this factoid and test the student.’ Of course, such an approach might prove cumbersome, and techniques like machine learning might automate it in some meaningful fashion using a data-oriented approached. Reminders are most effective when occurring just before the memory fades. Successive reminders will consequently be separated at longer and longer intervals[26].

In testing, there exists mainly three techniques for assessment:

- Reading, which is the reproduction of textual representations of the fact.
- Multiple choice, where one is allowed multiple alternatives, where at least one of them should be true. Often one or more of the alternatives are ‘the odd one out’, to test the student’s ability to discriminate irrelevant concepts.
- Generation, where the user is made to produce something, for example filling in a word. This technique is highly efficient with regards to retention, especially when combined with quick feedback[27].

Thus, we consider generation. An example of this might be generating a formally valid blueprint of some e-module, and asking the user what it does. Or it might be to make the user connect the relevant parts to make it work as desired. Thus, we foster true comprehension of the system mechanics and avoid cramming. As noted in the literature in the Memrise review, errorful generation might actually be beneficial, and the user should not be punished for making mistakes. Rather, we suggest to embrace it and make failure as smooth as possible, with quick iterations.

A big part of any learning system is the metaphor, or the user interface. The system needs to provide some incentive for the user to perform some action. Thus, the user interface will always be a question of demographics. We suggest that the user interface should be amenable to at least some simplifications to scale down to the technology-native elementary school demographic. Some concrete suggestions are:

- The user interface needs to take into consideration the rather poor motor skills of young children[28]. Thus, tap actions should not be that precise or responsive, but instead allow for some slack. For example, multiple taps should not result in multiple windows, but rather provide a time buffer for the action to launch. Also, the hit box of buttons should be greater than their actual size.
- Avoid splash screens[29], and in general get to the point as quickly as possible. Thus, it might be better to provide a simpler, but usable interface rather than a complete experience first-hand. E.g. one may wish to avoid modal dialogues, as they provide children which textual choice,
which they might not understand or be interested in.

- To provide some sense of continuity, and also a way of accumulating rewards, the user constructs an avatar. This concept is known from video games, and has already been suggested to be a viable way of familiarising children with complicated services like search engines[4].

Unfortunately, we were not able to locate high-quality sources of research in this area. Most sources are based on de-facto and ad-hoc solutions, with little or no scientific basis outside of in-house usability studies. Thus, we are potentially missing out on a great deal of useful data. On the other hand, this means we have the unique opportunity to not only be innovators, but also inspiring flagships.

**Takeaway points**, based on previous discussion and the reviews in Section 6.

- Spaced learning with testing using generation fosters comprehension and recall. We need to embrace generating errors as a way of learning.
- Quick and simple feedback with additive gains facilitate user engagement and learning greatly, and promotes attention continuity.
- The system should provide a simple (preferably physical) metaphor as part of its user story.
- The system needs to use open, free standards to enhance composition and foster a culture of reuse and experimentation.
- We should strive for feature parity between different clients, to simplify the user story and provide a consistent experience.
- A strong, data-driven approach involving the users strengthens community relations and improved quality by providing relevant feedback to create, enhance, or QA existing material.

So the big question then becomes what do we do with all these takeaway points. In order to provide a cohesive experience for authors as well as users we need to take all of this into account. But cohesion traditionally proves difficult when coupled with agnosticism — i.e. we would like to compose many — different — kinds of modules, and different kinds of modules likely have different approaches to authoring.

What we are eventually getting at is the need for high quality control in what modules we allow, and likely a fair bit of customisation of the ones we do end up allowing. Alternatively new module authoring software may be developed altogether.

6. Related work

H5P has rudimentary editing support. It is unfortunately low-level. But at the same time it appears to be easy enough to integrate, which is ideal for our system. At any rate, H5P does not offer high-level composing of modules, which is our real novelty.

There does not appear to be any mature, publicly available e-learning module authors that achieves the sophistication we would enjoy seeing, capable of making genuinely diverse modules, from flashcards to memory games, from quizzes to mini-games. This is another misfortune.

Intuitive composing seems virtually unheard of. And a standalone module-agnostic composing tool appears to be a complete novelty.

However, there exist several authoring tools for the specific things we wish to accomplish, i.e. there are flashcard authoring tools, quiz authoring tools, etc. In this section we discuss those, as well as authoring tools for completely different things, and unconventional ”authoring tools” like Minecraft.

6.1. Evaluation of Anki

Anki is a system for spaced learning. It works by organising facts (in a wide sense, like foreign words or parts of a map) into individual cards, which in part constitute a deck of facts about a
given topic. The user plays through the deck by going through each card and stating how easy it was to recall the fact. The software then replays cards depending on how good or bad the recall was until some threshold of recollection has been met. Bad recall would result in the card appearing more often, and vice versa. This algorithm is inspired by the SuperMemo system written in the 1980s[30]. The intuition is that we reinforce learning by recalling something just as we are about to forget about it.

Users are allowed to share, amend, or extend existing decks. While Anki primarily exists for the purpose of individual learning, the composable and free software format allows for others to take part in the learning experience. The software has enjoyed great popularity amongst several groups, most notably learners of foreign languages.

Anki is available both as a desktop client and through a web interface — AnkiWeb7. While the latter easily allows for online sharing of decks, it doesn’t allow for importing them. This is because it only synchronises with the desktop client. This highlights the challenges faced by desktop and web clients with different capabilities, and the value of isomorphic implementations.

AnkiWeb allows for synchronization and sharing of card decks (as files) using a free online service. It is also able to play through the decks, but not import them from stand-alone files.

The desktop client of Anki will therefore be the main focus of this evaluation, as it is the only full implementation of the system. Similar software in the same area are SuperMemo and Fluxcards.

In terms of licensing, Anki is well-aligned with our project. It is freely licensed under the terms of the GNU AGPL v3+. Sub-components are licensed under a variety of licenses, mostly GNU GPL and flavours of BSD/MIT licences. All art assets are also freely licensed.

6.1.1 Expressiveness

Anki allows for the authoring of (decks of) flashcards using standard HTML components with CSS styling. As a result, users are able to enrich cards with customised formatting, sound, and video. The users are also able to record their own voice (and repeat sounds) during play-through. This offers an interactive experience to the end-user. Since HTML and CSS are relatively flexible and well-documented technologies, and is used by many other prominent parties, this is likely a good choice by the Anki developers, that gives the users a good balance between expressiveness and ease of use, as well as familiarity.

6.1.2 Ease of use

Because the technologies used by Anki are freely available and readily documented, they constitute an open standard. This open container format makes Anki composable, and since the technologies are rather common (at least HTML), users can make relatively simple changes without any major obstacles.

However, Anki is considered to have a poor user interface interaction story for common scenarios[31].

An example of a problematic story is the rather common case of wanting to share a deck. This usually has to be done through AnkiWeb, a free online service, which allows the user to download new decks made by other users. However, no such suggestion is made to the user. Thus, the social dimension of Anki is downplayed.

Similarly, when using the software for the first time, the user is greeted by a shallow window with a single deck, and no explanation of Anki or its algorithm is given. The user can click a simple built-in test deck to play through it, but this is not suggested by the software, and the deck does not showcase Anki’s capabilities either (for example the use of rich media or LaTeX equations).

Other examples include the main window, which has both a menu bar and some buttons.

7https://ankiweb.net/
One of the buttons suggests that the user might be able to import new decks, but turns out to be about constructing new decks.

The most complex interface in Anki is the library view. It allows for somewhat non-trivial querying of all the decks in use, with numerous built-in categories and tags for distinguishing them (be it difficulty, topic, or the decks scheduled for today). Also, this rich view is not offered in AnkiWeb, so there’s an inherent divide in the capabilities of searching already imported decks and looking for new ones, limiting the ability to explore.

Universal design isn’t guaranteed since the decks are made by users. There doesn’t appear to be any way of filtering decks based on accessibility, nor any user-interface encouragement to do universal design when authoring decks.

6.1.3 Takeaway points

- Anki offers spaced repetition learning, which is an established and useful way of learning.

- The simple metaphor (a deck of flashcards) is intuitive and easy to explain to users\[32\], and simple enough to implement.

- Anki’s use of HTML elements provides a universal container format and facilitates sharing. However, the web interface is very limited, and while it does allow for sharing, it does not allow for importing decks, thus not providing a full (isomorphic) user experience across platforms.

- The desktop client has a problematic user interface story, and does not provide enough directions or examples for effective use. Modal dialogues and context switching might provide a more elegant solution for capturing common usage patterns (compared to displaying the full set of choices and categories available to the user, e.g. in the library view).

6.2. Evaluation of Memrise

Memrise\(^{8}\) is a flashcard-based learning system. The cards make use of (often crowd sourced) mnemonics combined with spaced repetition (akin to Duolingo and Anki) to augment the learning experience. It is unique in part due to its openness regarding its techniques and its close ties with academic researchers, who are allowed to analysis its datasets.

Memrise itself suggests three basic techniques:\[26\]

- **Elaborate encoding.** I.e., the construction of cognitive structures of already known material that new knowledge might ”attach” itself to. E.g., taxonomies (like the colours red, white, blue) are easier to remember than a random list (astronaut, velvet, cigar). To this end, Memrise uses crowd sourcing (with machine-learning techniques) to suggest ”mems”, which are the aforementioned cognitive structures to boost learning.

- **Choreographed testing,** which test recall and comprehension. Memrise varies between simple one-off challenges ("casa = ?") and multiple-choice questions to keep things interesting.

- **Scheduled reminders,** which is their implementation of spaced learning.

Research around — or by — Memrise mostly revolves around the benefits of testing, error generation (vis-à-vis inerrant learning), and how spacing affects the efficacy of the learning programme.

Testing is the act of challenging retention while studying, which is beneficial as part of the learning process. There is no consensus as to why it works, but some explanations include that it increases the storage strength of memory, and that it generates additional cues that creates (potentially more efficient) routes through memory\[27, p.6\].

Generation (with feedback) is an active form of learning, and requires the student to complete

\(^{8}\)http://www.memrise.com
something, for example a sentence ("Lisa is a __"). before getting to know the answer. This is contrasted to reading, where the student absorbs textual material and definitions, and multiple choice, which amongst other things tests the ability of the student to see how the different alternatives relate to each other (finding the odd one out etc.).

Errant learning has been thought to be detrimental to learning as people recall their errors to a greater extent than their correct answers[27], but this research has mostly been done with already memory-impaired populations, which might have different requirements. Errant learning does not seem to be as effective as error generation: “…” generating responses followed by feedback is helpful to memory even when many errors are generated, compared with inerrant studying without generation[27, p.54].

Generating errors may benefit vocabulary learning even when there are no established associations to the items in question[27, p.54]. While completing sentences appear to have the biggest advantage over only reading, other types of generation also improves test scores when compared to reading by itself[33, p.73].

Several experiments have been designed to test assumptions regarding these models. They are mostly language-orientated (a good fit for a programming language!), and might use techniques like archaic words (which are certain to be unknown for most test subjects) to provide a "clean slate" for testing comprehension and retention of definitions. Research shows that participants’ perception of learning is influenced by error generation, and that participants seemingly perceive generate items as more difficult to learn, which may lead to participants putting in more effort to learn the more difficult items, which in turn may lead to higher retention[27].

6.2.1 Expressiveness

More or less any knowledge that needs to be internalised can fit within the style of testing offered by Memrise. Users are allowed to create their own courses, which may contain multimedia levels. For example, users may embed videos from Vine9 inside “mems” to boost retention.

6.2.2 Ease of use

Memrise offers an easy to use interface with a few, mostly obvious buttons. Flow doesn’t seem to be problematic. Interactive modals guide the user through things like creating “mems” for their own courses and so on.

6.2.3 Takeaway points

- Generating (that is, having the student do something) is provably more efficient than either reading or quizzing.
- We need to embrace generating errors as a way of learning, and give feedback as quickly as possible to promote retention and comprehension.

6.3. Evaluation of Duolingo

Duolingo10 is a solution that provides spaced, paced learning. Users are presented with different challenges, usually centered around words (for example their pronunciation), and are able to advance through a hierarchy of lessons. Upon completion of lessons, modules, levels etc., users are granted experience points, which can be spent buying more attempts, in-game apparel, and so on. On completing levels, the overall retention of the lesson is noted using a strength bar. As time goes by, this retention decreases, and the user is prompted to re-take lessons, not dissimilar to the system provided by Anki.

Users are able to perform simple tasks like translating individual words or sentences, pronouncing them correctly (using a microphone), conjugating nouns and verbs, and so on. These tasks usually come in sets, and such a set in turns constitutes a module or level in the game. However, progression need not be linear, and more proficient users can opt to perform tasks

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9https://vine.co/
10https://www.duolingo.com
qualifying for more advanced modules early on if so desired.

When performing a task, the user has a given set of hearts or HP (hit points, an analogy from games). When they fail a task, the count is decremented. Users can also opt for timed lessons.

6.3.1 Expressiveness

Duolingo is proprietary software that does not offer a way for users to author their own assets, and instead seeks to keep them content by providing it with the program.

Duolingo allows users to translate texts to (im)prove their language proficiency, and uses community filtering to ascertain the quality of the translations. This is how the service pays for itself — as a mechanical turk for natural languages, currently partnering with CNN and Buzzfeed[34]. It also provides language certification services[35].

Users are able to provide feedback on tasks, for example whether a translation is reasonable or too hard at this proficiency level.

Duolingo tracks metrics, like what lessons people struggle the most with, adopting a wholesome data-driven approach. This combined with a flexible userbase allows them to iterate quickly on the assets provided in the lessons[36].

But in terms of actually contributing with learning material, DuoLingo has nothing to offer.

6.3.2 Ease of use

Duolingo appears to be easy to use. Quick feedback and positive reinforcement makes it easy to start using the system. There aren’t many options available, except for audio settings (and other preferences), which makes the user interface easy to use.

6.3.3 Takeaway points

- Quick and simple feedback with additive gains facilitate user engagement greatly.
- Community can be used to enhance or ensure the quality of lessons.
- A data-driven approach might foster good community relations and provide more relevant, better assets as well.

6.4 Evaluation of RPGツクール

For something different, let’s consider RPGツクール (RPG Tsukuru). It’s a game authoring tool wherein users create worlds through a tile-based map editor, and breathe life into their worlds by scripting actors, events and objects. Users may import their graphics and scripts, or use some of the wealth of art assets, scripted events and characters that are distributed with the program. The series is primarily successful in Japan, with English translations being a rather new thing.

While the main reason for us considering RPGツクール is its engaging user interface, it has in fact been used successfully for teaching. Authoring games in RPGツクール has proven successful in teaching mathematics[37], and games authored in RPGツクール have been used for encouraging programming students[38]. It is no secret that authoring and playing games is a sound way of both encouraging learners and increasing their efficacy.

RPGツクール assumes little or no experience in programming or designing games, and can as such be said to be aimed at newbies. However, several very successful commercial computer games by experienced developers were authored using RPGツクール.

6.4.1 Expressiveness

RPGツクール is primarily aimed at making Japanese Role-Playing Games such as the old ファイナルファンタジ (Fainaru Fantaji) or イース (Isu) games. The user may design tile-based 2D overhead-view maps with different types of graphics for the tiles, representing grass, ocean, and so on. Sprite sheets are used for animating characters. The user can script events and design a program flow through this.

Designing a map can in many ways be compared to using a bitmap editor. What You See Is What You Get. Authoring art assets outside of the ones that are distributed with the program is usually done with dedicated tools, such
as using a video editor for making cut scenes, or an audio editor for making sound clips, or a bitmap editor for making sprite sheets. More recent versions have tools such as the character generator in which sprite sheets are actually generated by having the user choose settings such as the hair style and skin colour of the character they wish to generate.

The scripts for events and game objects in general are very powerful. The programming language Ruby is used in recent versions. Ruby is a fully-fledged Turing-complete programming language. The tool provides several high-level constructs to facilitate the scripting. Additionally there are tools for authoring scenarios and events through graphical user interfaces, comparable to the character generator.

6.4.2 Ease of use

The latest edition of RPGツクール boasts being “simple enough for a child; powerful enough for a developer”[39]. While certainly (theoretically) powerful, professional reviews are less than kind when discussing the user interface[40] — just like they’ve historically been unfavourable to the series[41].

However, interestingly, user reviews seems very positive on most sites[42, 43, 44]. And even more interestingly, most user reviews that explicitly mention the user interface are very happy with it, calling it “clean” and “intuitive” amongst other things.

The map editor is simple and intuitive to anyone who’s ever used a bitmap editor of any kind. But the plethora of nested menus that needs to be endured to do anything else is unkind to the overall user experience. Add to that a poor overview, complex games quickly burdens the mind with the need to remember how your pieces all fit together, if they do so at all.

It may appear user reviews focus more on virtues of the map editor, whilst professional reviews can’t get past the troubling interface for game objects in general.

In order to fully take advantage of the program, one arguably must learn the Ruby programming language to master scripts. Although we can hardly criticise RPGツクール for facilitating truly knowledgeable users, a better user-interface design might have bridged the gap to non-programmer users.

6.4.3 Takeaway points

- What You See Is What You Get is well-liked amongst users.
- Horribly complicated nested menu systems are, uh, well, not well-liked amongst professional reviewers...
- Authoring games can be a successful way of learning.
- Playing games can successfully motivate learners.

6.5. Evaluation of LateralGM and ENIGMA

LateralGM[11] is a free tool to author and edit games. It aims to be compatible with the file formats of Game Maker and the newer GameMaker: Studio, and has a user interface very similar to that of Game Maker. To compile and run games, LateralGM normally interfaces with ENIGMA[12], which is a compiler and runtime system aiming to be backwards compatible with Game Maker games.

6.5.1 Expressiveness

LateralGM and ENIGMA form a multi-genre game authoring tool with features that make it easy to use for beginners, but also powerful for advanced users. Although the scripting language has some support for 3D graphics[45], the software mainly focuses on 2D graphics and gameplay.

LateralGM presents the game as a set of different resources, including sounds, background images, sprites, scripts, fonts, objects, and

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11https://github.com/IsmAvatar/LateralGM
12http://enigma-dev.org/
rooms. Users may edit sounds and images within a game using external programs.

Objects may be programmed to act on various events. Events include the “step” event (fired once in every update cycle, e.g. 30 times per second), user input, collision detection, timers, action-/script-triggered events, and many more[46]. Each event can be programmed using either drag-and-drop actions or scripts. The set of drag-and-drop actions is extensive and includes basic flow control, and may also be extended with action libraries.

Each object can be set to use a possibly animated sprite, which causes each instance of the object to be drawn with that sprite. This sprite may also be used for collision detection. The “draw” event is also available for producing more advanced graphics. Objects may also be set as invisible, appearing in the room editor and possibly providing collision detection with the associated sprite, but not visible during gameplay.

The room editor allows users to graphically place instances of objects, either freely or in a configurable grid, inside a room as they will appear in the game. The user may define multiple layers of background and foreground images, either as whole images, possibly repeated or stretched, or in the form of placeable tiles, using the image as a tileset.

LateralGM loads and saves games in the proprietary file formats of various versions of Game Maker. These file formats are not officially documented, but have been reverse-engineered by LateralGM developers[47]. While LateralGM and ENIGMA aim to be compatible with both current and earlier versions of Game Maker and GameMaker: Studio, several of these versions of Game Maker have incompatibilities between themselves. Not all features are implemented in LateralGM and ENIGMA, and development is struggling to catch up with later versions while still being compatible with earlier versions.

6.5.2 Ease of use

LateralGM lets users make simple games without writing a single line of code, using only drag-and-drop actions and graphically placing object instances in each room. Parameters to the actions may be given as scripting language expressions, providing a smooth learning curve from simple actions to the full scripting language.

6.5.3 Takeaway points

- Drag-and-drop can be used together with a written programming language for a very smooth learning curve for non-programmers.
- Trying to keep up compatibility with proprietary tools and undocumented file formats is difficult and may take more development resources than available.

6.6 Evaluation of Minecraft

Minecraft[13] is a modern open-world (sandbox) game. It allows the user to freely place, as well as craft (potentially new) blocks in the game. Thus, it is possible to build whatever imagination and time allows for in the game. The game is very popular, especially with the younger demographics, and has been noted for its ability to inspire creativity in its users[48].

Being a virtual world, and due to its popularity and game mechanics, it has been suggested as a tool in primary and secondary education. Partly due to its potential for stimulating a sense of presence in the students[49], which games in general are notoriously successful at.

In the area of situated learning, Minecraft tends to be classified as a multi-user virtual environment, which is of particular interest to teachers and students alike. But it is a category of situated learning which tends to suffer from some common issues, ranging from standardisation (can others extend it?) to time (how quickly is the user able to use the game?)[50]. Due to its unique proposition of low cost, huge popularity,

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13 https://minecraft.net/
and innate creativity, Minecraft seems to offer a novel platform for learning to take place\[49\].

6.6.1 Expressiveness

Minecraft is very expressive in allowing the user to roam freely, harvest resources, build structures, and craft new tools. As such, there are many modifications available to extend the game with new functionality, like energy systems, or new entities. There is currently no official application programming interface for developers of such extensions, and most of the extending is done using disassembly and patching the game locally.

Minecraft offers a primitive realisation of boolean digital circuits named “redstone”. Redstone is a resource found in the game, and might in its harvested state be placed on the ground to carry signals. Redstone carries either a logical low (false) or high (true) signal, which can be (de)activated through a number of means, for example levers. Redstone can also be used in recipes to craft new blocks like signal repeaters or switchable lights.

More notably, the redstone system in Minecraft is able to emulate the primitives needed to construct any analogue circuit. Thus, people are able to construct everything from simple systems that open doors, to full-on 8-bit processors\[51\]. Thus, the redstone system offers an interesting value-proposition: Mojang has successfully fooled hundreds of thousands of children and adults alike into understanding primitive digital circuits. By correspondence, they understand some set of boolean algebra, making them capable programmers as well.

6.6.2 Ease of use

Minecraft is readily accessible, but has a steep learning curve\[48\]. Systems like TooManyItems\[52\] makes the game slightly more accessible by making it easy to peruse recipes, aiding discovery. However, Minecraft itself provides little of a set path for playing the game, save a final boss fight, which is optional, and pretty much orthogonal to the ordinary game mechanics.

6.6.3 Takeaway points

- There are a number of issues with using virtual worlds in situated learning. Minecraft provides a reasonable solution to many of them.
- Seemingly complicated topics (like circuits) can in fact be taught to children, given the right incentives

6.7. H5P

H5P is a standard allowing for reusable, portable e-learning modules. It does so by providing plugins for Drupal\[14\], WordPress\[15\], and Joomla\[16\], along with a file format specification for distribution, as well as standard content types with built-in editors.

The value proposition of H5P is that it integrates nicely with existing infrastructure like databases and view layers, enabling developers to focus on developing their modules.\[53\] I.e., it reduces the ceremony needed to get going. Moreover, its portability provides a much-wanted ease of deployment for site owners, as well as a bigger market for developers.

Before deciding whether to use H5P we needed to evaluate five core issues.

6.7.1 Are the abstractions offered by H5P powerful enough?

At its very core, H5P offers a contract for libraries, which might function as full-blown applications, stand-alone libraries, or application programming interfaces for any combination of the above.

This is done in part by making the libraries document their semantics (‘semantics.json’), i.e. the properties (data structure) that are used to set up the application. Each property is

14http://www.drupal.org/
15http://wordpress.org/
16http://www.joomla.org/
described by its name, as well as its type. Different things have different semantic requirements: E.g., the ‘list’ (ordered group) semantic type requires the name of a single entity in it (‘entity’). This information is used by the generic editor to allow users to easily customise the library.

H5P also provides a container format that manages ceremony, like loading the appropriate CSS and JavaScript files, as well as providing useful metadata like the version and name of the library. This format includes a JavaScript class which libraries extend to hook into H5P. Applications are required to implement an ‘attach’ method, which accepts the identity of the container in which to attach the module.

Of particular interest for us is the central event dispatcher (‘H5P.EventDispatcher’), which is used to dispatch actions within H5P[54]. Thus, like Elm’s ports[18] or Facebook React’s Flux architecture/dispatcher[55], a synchronous interface for internal communication is provided, which might prove useful for multi-component systems.

Beyond this, H5P leaves the library developers plenty of room to expand. The H5P standard is pretty much “open world” and doesn’t necessarily limit the structure of functionality of the JavaScript libraries it wraps, enabling developers to make arbitrarily complex software.

However, it should be noted that H5P still depends on professional developers, and doesn’t provide primitives that necessary make any sense for ordinary users. Therefore, the standard per se doesn’t preclude a more user-oriented canvas system.

In conclusion, H5P doesn’t itself provide the needed abstractions necessary, but doesn’t hinder them from being developed. We can use H5P for now.

6.7.2 Are the abstractions high-level enough for our purposes?

Given our emphasis on an intuitive user-interface for liberating the BOP, H5P quite frankly doesn’t cut it for the time being. But even if H5P is not nice enough to use (at the moment) for non-technical users turned authors, it does play nice with other software — or, at the very least, it stays out of the way. This is very desirable to us.

Once we have H5P modules “up and running”, so to speak, there’s nothing stopping us from moving ahead with other kinds of e-learning modules. There is furthermore nothing precluding H5P being improved in the future; we could even conceivably do that ourselves.

The honest truth is that H5P is not good enough for our intended target demographic. But it is free software that integrates nicely and may be improved in the future. We’ll take it.

6.7.3 Can we generate valid H5P modules?

Yes. Another short answer, but a more positive one at that.

As already noted, H5P doesn’t limit any system wrapped in its container format. Therefore, any functioning JavaScript system could in principle be embedded within a H5P module, provided it only operates on a single node (due to the complexity and performance implications of coordinating DOM operations on overlapping elements).

6.7.4 Can we import H5P modules?

Again, yes! We can! We would need to make something that would be able to parse the semantic definitions of H5P modules, and we’d have to use this in some meaningful way. Effectively we should enhance the authoring tool as well to make it more appropriate for our target demographic.

6.7.5 Can we offer a new way of composing H5P?

H5P has no composition guarantees, and resorts to Design by Contract (DbC) for composite systems.[56] This does nothing to ensure a uniform communication standard, which ensures flexibility, but does not provide a uniform interface. The specification itself admits that this is due to the lack of interfaces in JavaScript. Thus,
the contracts are more by politeness and not by obligation, potentially creating weak implementations.

Therefore, there is obviously definite value to be provided by a system providing more stringent, verifiable contracts between components, for example using a more powerful type system than the one found in JavaScript. This might in turn result in more reusable and robust applications. Also, because H5P effectively provides no composition contracts, this system might function as a sandbox and provide useful feedback should future versions of H5P seek to provide more formal requirements for composite modules.

One related problem is that H5P provides no standard for sub-module inheritance/reuse of content, as the system only has a notion of full H5P modules. We must figure out a way for several modules to refer to the same data.

7. Conclusions and further work

Our idea is a canvas for composing e-learning modules, initially targeting H5P. It should be intuitive to use, yet potent enough to make sufficiently refined modules. A simple user interface is vital to construct a ladder out from the BOP, whilst a capable set of features is important to attract users in general. Via gamification, users are encouraged to share their modules, and to improve the modules of others. We encourage a self-regulating community that promotes quality through a rating system for modules.

By authoring modules, the student becomes the teacher, which leads to more effective learning. Learning by teaching is a powerful concept that enhances the self-efficacy of students.

The canvas system is an important step towards our goal. However, much remains to be done. We need to achieve a cohesive authoring experience. Either by making our own modules, or by figuring out a way to make e-learning modules authoring agnostic and cohesive at the same time.

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A. Design document

This is the design document authored for our system. It is authored by a user experience expert, Lene Thuseth, as we felt the interface emphasis warranted professional involvement.

While it certainly does not cover all of our ideas, it does showcase the core subset of what we envision in a minimum viable product. More importantly, it brings our user-interface research observations to life, and shows the fundamental interaction pattern and establishes the ever intangible “look’n’feel” of our system. The shapes, colours, fonts, and overall presentation is given careful thought. This is all described and explained in the document.
DESIGN DOCUMENTATION

Enabling Learning By Teaching: Intuitive Composing of E-Learning Modules

21st of October 2015

Author: Lene Thuseth
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THE IDEA

The idea is to make a highly intuitive and engaging system to compose e-learning modules. The system will support authoring of both linear and non-linear e-Learning\(^1\), and is designed with an emphasis on younger users. In the MVP (Minimum Viable Product) the system will allow users to compose H5P-modules ([h5p.org](http://h5p.org)) with an unmodified version of the H5P composing tools.

The design and concept is based on research done and published by plaimi ([secure.plaimi.net](http://secure.plaimi.net)). More information on market research, target audience and the concept itself can be found in their paper\(^2\).

"In an effort to foster learning by teaching, we propose the development of a canvas system that makes composing e-learning modules intuitive. We try to empower and liberate non-technical module users by lowering the bar for turning them into module authors, a bar previously set far too high. In turn, this stimulates learning through teaching. By making a damn fine piece of software, we furthermore make module authoring more pleasant for experienced authors as well. We propose a system that initially enables users to easily compose H5P modules. These modules are successively easy to share and modify. Through gamification we encourage authors to share their work, and to improve the works of others."

*Abstract from the Enabling Learning by Teaching: Intuitive Composing of E-Learning Modules paper*

The focus of the concept is to foster "learning by teaching", by encouraging students to make and share e-learning modules, and re-use and re-mix modules made by others. At the same time we make it much easier for professional e-learning authors to make engaging and adaptive e-learning.

The design itself will have a heavy focus on all aspects of usability, including universal design (accessibility), motivation by gamification, and how intuitive and easy it is to use and navigate the system.
THE DESIGN

The look
Because children are the primary target audience, the design makes use of bright colours, strong contrasts, big buttons, playful avatars, and a friendly language. At the same time kids aren’t the only target audience, so the design also needs to appeal to a more mature audience. By using bright but slightly muted colours we achieve a colour palette that looks fun and child-friendly but not too childish. This also gives it a modern feel.

Round shapes such as circles and rounded corners feel friendly and playful, enticing the user to play with the system, and that is exactly the message we want the design to send; “come play with me, come have fun!”

Big buttons and strong contrasts also help the user navigate the system, by making it obvious how to interact and where to click. By having a tidy interface with only the necessary functionality available, we avoid confusion and frustrating the user. The less time the user spends trying to figure out how to use the system, the more time they can spend on the actual task.

Buttons that can be clicked use visual effects such as gradients and shadows to make them appear elevated from the surface. People intuitively know that they can click these buttons.
The language

By using a casual and friendly language we try to introduce a sense of humanity and human touch to the system. It feels like your friend rather than a cold and robotic system. We make use of an avatar that will pop up with hints to help the user along, or to let them know when they’ve done something wrong. We don’t want to give kids a feeling they’ve done something wrong, so even when there’s an error message it is phrased in a positive and friendly manner.

Instructions on buttons and actions are clear and concise. We use the terminology *find* rather than *search*, and well-established terms such as *undo* and *save*.

The language aims to be fun and easy to understand for kids, but clear and comprehensible for adults.

We use metaphors to make something a little bit complex, such as flows and forks, more understandable. Since the avatar is an otter, we use the metaphor of rivers and dams when we talk about the flow through the modules, and possible broken logic that impedes the flow. This can help make a complex concept seem much more understandable for kids as well as adults, and help them author complex e-learning modules/courses.
**Functionality and responsiveness**

The most important thing of a system of any kind is its functionality. It doesn't matter how beautiful it looks if it doesn't feel responsive and logical. It needs to give prompt feedback when actions are performed, so the system feels alive and responsive.

We have no splash screens or loading bars. Actions lead to an instant response, e.g. if a user searches for something, the search results populate as they type giving instant feedback to their actions. Kids, especially, hate waiting, and will not have the patience for fancy splash screens. Therefore the user may jump straight into the task with no delay as soon as they enter the system.

Our focus on responsiveness is further emphasised by things like hover effects for mouse-users and on-tap effects for tablet users. When you hover a button, its colour will change, and it will animate (e.g. wiggle) in order to convey a possible interaction. Furthermore, when the button is clicked, its appearance changes as a visual feedback. As an example the ‘CONNECTIONS’ actions are in a toggle bar where either one or fewer of the actions can be active. When one action is activated the mouse cursor changes to indicate the action that can be performed, e.g. the ‘DRAW’ function transforms the cursor into a pencil.
Functionality and responsiveness (cont.)

The more complex ways the system is responsive and feel alive, is by understanding a user’s behaviour. If they fail at a task or take too long to do something, the system will assume the user might need help with what to do. One example is if the user starts the system and doesn’t do anything within a certain time limit, the avatar will pop up with a hint on how to get started. If a user starts performing actions right away, this hint will not appear. The same hints will not appear more than once.

Another example is if the user breaks the logic of a connection. The hint will pop up telling them that their latest changes has caused errors in their flow, and how to fix it.

All ‘big’ actions such as ‘CLEAR ALL’ will have an extra layer of confirmation before the action is completed in case of enabled by accident. All actions can be reversed with the undo function or re-done with the redo function.

We never use just icons for important functionality, but include text labels as well. The only exception is when the narrow side bar is active by choice of the user.
**Consistency**

To improve a system’s usability, the navigation needs to be consistent. If a button does something different in one place in a system than it does in other places, the user may get confused and frustrated. Consistency improves predictability, which in turn increases learnability (how quickly a user learns how to use the system).

This system has very consistent navigation. An example of this is how the module icon can be interacted with. If the module icon or magnifying glass icon is selected, the info box will pop up. This action is available no matter where the icon appears. The magnifying glass icon indicates that the module isn’t empty, unlike when the icon is on its own when adding a new module. As soon as the module is authored, the magnifying glass is added to show that the module is no longer empty. From this info box, the actions are contextual, but the navigation is consistent and can therefore be predicted and expected by the user. The actions appear in order of importance, ‘ADD’ is more important than ‘EDIT’ (as it allows for quicker use), and ‘EDIT’ is more important than ‘DELETE’.

There are also colour consistencies in buttons across the system with similar actions.
Animations and transitions

Another way to enhance the feeling of consistency is by applying animations when transitioning to a new page by clicking a button. A context shift can cause unease if it’s not visually expected. By using animations, such as morphing, we can ease the transition for the user.

As an example we have the two buttons in the toolbox default view; ‘Find module’ and ‘Make new’. When clicked these will transition into respectively the search page and the make new page. We ease context-switching with animations. E.g. by morphing the search button into its new state, and leaving it active for the user to type into straight away, we create a much less confusing context-switch.

Similarly, the two buttons will move and morph into their current appearance on the “Make new” page rather than just appearing in their new states.

By selecting the cancel buttons on each of the new screens, it will morph back into its previous state.
Gamification

Gamification is when you apply game mechanics and metaphors to non-game scenarios in order to motivate and engage people to reach their goals.

Our system will be gamified, with the use of customisable avatars and achievements, and with the look and feel of a game, by allowing the user to drag items around freely to accomplish their goals.

We use gamification, especially to motivate learners to share and re-use other people’s modules. We do this by awarding achievements for re-using modules, and for having modules that are frequently re-used. To prevent meta-gaming* we can add an ‘influence’ system, wherein a module gets a higher score if used by more unique users. The influence system influences module popularity.

Users may customise their avatar, which gives the feeling of having their own personal helper. This creates more attachment and loyalty to the system, and makes it feel more like a friend than a computer system. Gamification elements like these make the user feel more involved, and in turn more engaged in the task that they are doing.

*Exploiting the game mechanics in order to achieve a high score.
Universal design (accessibility)

Our system will be a website. One of the main motivating factors for this decision is that we want our system to be available to as many people as possible. This means we need to support the most popular operating systems and devices. This also means we need to take into account accessibility software such as screen-readers. Our system aims to follow the WCAG2.0 requirements as outlined by Difi. (uu.difi.no)

We do this in several ways. One way is making sure all colours have a high enough contrast ratio, and that we don’t use colour by itself to indicate things. An example is the connections, which appear red or green, depending on whether the logic is correct or not, that also have an icon in a different shape to indicate the same thing.

The primary way of navigating the system relies on drag-and-drop, but we also have alternative methods of navigating. E.g. the icons may be dragged to the canvas, or they may be selected, at which point an ‘ADD’ button will appear. Selecting this button is functionally equivalent to the drag-and-drop action.

We use large buttons with larger hit-boxes because children are in the target demographic. E.g. the module-button: activating the module icon does the same thing as activating the magnifying glass. The magnifying glass serves primarily as a visual indication.
THE CONCEPT

The essence

What makes this product so unique, is that it makes it easy for anyone, regardless of age, background, or technical ability, to author sophisticated non-linear module structures. This is something that previously has only been available to professionals working in complex systems. Our system is so intuitive and easy to use that the user can focus almost entirely on the task at hand.

The biggest drawback at this stage is the complicated and not very user-friendly H5P authoring system. However, this can be seen as an opportunity to work on the user experience of the H5P-system. This will in turn benefit H5P itself and every user of it, including our system. Additionally, the authoring capabilities of future e-learning modules might be designed to support our system from the ground up.

Research done in the earlier stages of this project indicate that there are several operators in the market that have some of the same features that this project has, but none that do exactly what we aim to do. There are many module authoring systems, and many e-learning systems for kids, as well as several canvas systems where users can design their own games or experiences. But there are none focussing on visual and intuitive authoring of e-learning modules. Nor any focussing on the learning by teaching effect. By using gamification to encourage students to share, use, and improve other people’s work, we allow for a growth culture for social learning. We encourage problem-solving via gamification. The user is free to move items around on their “canvas” as they please, and visually build up their course, with actions and consequences.

A student can easily author a non-linear module by using if-expressions. E.g. if the score of a module is less than 80% then go to this module, if not proceed to the next module.

The system helps the user formulate if-expressions. E.g. the user has four modules, A, B, C, and D. They connect B to A with the condition of a 50% completion score of A. They then connect C to A with a 75% completion score condition. Finally they connect D to A. D then automatically serves as a “catch all”, by catching all scores less than 50%. The users are of course allowed to overrule this, but then they also have to fix the broken logic.

A good way to encourage kids to learn is to involve them in their learning, and a great way to involve kids is to let them have fun. This is a key feature of this project; making it FUN and EASY to learn and develop e-learning.
THE SPECIFICS

01. Colours, fonts, and styles

MAIN COLOURS

| Colour | Code       |
|--------|------------|
| MC1    | #00B0BC    |
| MC2    | #009CA7    |
| MC3    | #2D2F37    |
| MC4    | #C1DA83    |
| MC5    | #AFC176    |

SECONDARY COLOURS

| Colour | Code       |
|--------|------------|
| SC1    | #40C4CD    |
| SC2    | #73D4DA    |
| SC3    | #E5F7F8    |
| SC4    | #42444B    |
| SC5    | #616369    |
| SC6    | #76787D    |
| SC7    | #F4F5F5    |
| SC8    | #D0E3A2    |

FONT

EXO
https://www.google.com/fonts/specimen/Exo

Used for most text

Lato
https://www.google.com/fonts/specimen/Lato

Used for better readability of numbers, used in info-popups and tool-tips.

SHAPES AND SHADOWS

The design is based on circles and rounded shapes. Shadows are used to indicate interactivity. Bigger shadows are used on most important buttons, darker shadows on dark backgrounds and lighter shadows on lighter backgrounds.
02. Initial view and interface

As already mentioned there are no splash-screens, loading or extra clicks to get into the system, you start playing right away.

To make it clear and simple, only a few actions are presented when you start off. The highlighted feature is the ‘Find module’ (1) as we want to encourage users to mainly re-use already existing modules. There is also a button to ‘Make new’ (2) module, which will use said modules authoring tool.

In addition you can ‘OPEN’ (3) a project, ask the avatar for ‘HELP’ (4), and view profile options by selecting the avatar picture. All unavailable functionality is clearly marked as such, and there is a textual hint that tells the user what they need to do to start.

If the system detects that a user spends a while without doing anything, it assumes the user is new, and a welcome message pops up. With a login-system or caching, the system would know only to do this the first time. By having a delay we avoid bothering users that actually know exactly what to do, and start off right away.
03. Additional functionality on initial view

Other functionality can be added to the initial view to motivate users, such as a list of some of their ‘FAVOURITES’ (5) or a list of their ‘RECENTLY USED’ (6) modules. Other functionality could include a list of the ‘MOST POPULAR’ modules, based on the influence score mentioned earlier.

Modules can be interacted with from these lists as well, indicated by the consistent design. If the user selects a module the module info box will appear (7), like it will other places in the interface. They can also drag these modules straight onto their canvas.

One problem that needs solving is how to suggest relevant modules. If a student is creating a course about Africa, then modules about algebra aren’t very relevant, and serves more as a distraction than anything else. One possible solution is displaying suggested modules based on their search results.

Other functionality that becomes available when appropriate is ‘UNDO’ (8) — that reverses the last action, ‘REDO’ (9) — that undoes an undo, ‘SAVE’ (10) — that allows the user to save their project, and ‘CLEAR ALL’ (11) — which clears the whole canvas. In addition the canvas may be zoomed in and out, by either scrolling or by using the ‘+’ and ‘-’ buttons (12) in the lower right-hand corner.
04. Expand/shrink the sidebar

To afford more room to the canvas, the left-hand side bar can be shrunk to a narrow bar with only icons. As a rule, we have text labels for all important functionality, but on the narrow bar we use only icons to save room. If the user is unsure of what any of the buttons do, they can simply expand the bar (13) to see the full buttons.

The ‘FAVOURITES’ (14), ‘MOST POPULAR’ (15), and ‘RECENTLY USED’ (16) buttons will result in the same action as the ‘See all’ (for ‘FAVOURITES’) or ‘See more’ (for ‘MOST POPULAR’ and ‘RECENTLY USED’).
05. Find module

The ‘Find module’ panel is the only panel on the side bar that cannot be shrunk to a narrow version. Instead a ‘CANCEL’ (17) button appears. When selected the user is directed back to the previous screen. This panel takes up twice as much space as the normal side panel, to allow for extra information such as ‘SEARCH FILTERS’ (18) and ‘RESULTS’ (19).

The search field itself appears active and ready to be typed into when the user clicks the ‘Find module’ button, to avoid having them click a second time. (20)

The user can apply search filters before or after searching (21 - next page). Search results will be listed as module icons with the same appearance as elsewhere in the system (22 - next page), and can be dragged and dropped onto the canvas from there, or added by using the ‘ADD’ button (23 - next page).
06. Make new module

The current interface for making new modules has 6 basic H5P-types. Quiz is the question set H5P-type, whilst the others retain their H5P default name and icon.

The 'Make'-panel can be shrunk into a smaller side-panel (24) with the same functionality.

Hitting 'CANCEL' (25) will take the user back to the previous screen. The 'Find module' button (26) is preserved in case the user changes their mind, and want to re-use an existing module instead of making a new one from scratch. It is less prominent and in a different location from the default view, but with the same look and size. This, along with morphing transitions, will indicate that the button is functionally equivalent in both places.

When the user chooses to add a module, they can either drag-and-drop the icon from the side bar onto the canvas (27 - next page), or they can select it and select the 'ADD' button that appears (28 - next page). The whole interface is darkened in response, so that the drop-zone is highlighted.

When dropped onto the canvas, the relevant module editor opens (29 - next page). Once the module is authored, it will appear on the canvas (30 - next page).
07. Make connections

When two or more modules are added to the canvas, the side-menu will change to include a new action: the ‘CONNECTIONS’ (31). This is a toggle-menu, where the cursor will change depending on which action is active. E.g. when the ‘DRAW’ functionality (32) is active, the cursor turns into a pencil (33) that allows the user to draw connections between modules.

Once the connection is successfully drawn (34 - next page), the system will align the connected modules appropriately to create a more neatly organised system. (35 - next page). With only one module connected to the preceding module, the default condition on this connection will be that the second module follows the first, or that the score of the preceding module needs to be more than 0% (36 - next page). This can be overruled by the user, to allow for complete freedom, but the system will then indicate that the logic is broken for that particular connection, and that they need to fix it. The avatar will show up with a friendly warning the first time this happens (37 - next page), as well as the visual indicators on the module structure itself, with the connection turning red, and a triangle exclamation mark appearing in place of the green tick icon.
Hmm... The logic got broken with your latest changes. Remember the water can't flow in a blocked river! Try to fix what's wrong, and if you can't figure it out just ask me!

GOT IT!
08. Demo

When a module is selected (38), the module info-panel will appear. This allows the user to see details about the current module, such as who it was made by, when it was made, how many times it has been re-used and re-mixed, and what type of module it is. From here, they may also edit or delete the module.

Additionally, when a module that has connections going from it is selected, a new menu item called 'CONDITIONS' (39) appears. This describes how many conditioned connections this specific module has. A button that allows the user to view these conditions (40) also appear. This will highlight the conditions that belongs to this module.

When a lot of modules are added the canvas may look cluttered on a small screen (41 - next page). One way to see more of the canvas, is by shrinking the side panel, (42 - next page) or by zooming out (43 - next page) the canvas. The heads-up display notifications retains their dimensions in order to preserve readability.

If a user’s device has a large screen, the interface will adapt by giving them a larger area to operate in (44 - next page).
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