VIDEOGAMES FOR TEACHING CODING TO CHILDREN AND YOUNG ADULTS AT THE LIBRARY

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As programming has become an increasingly valuable skill in the modern world, many public libraries have sought to help their young patrons achieve this new form of literacy. Often, video games have served as a natural ally in this goal since they are one of children's first and favorite introductions to the use of computer technology. However, the wide variety of software available makes choosing the best games for individual public libraries' collections difficult. A wide range of factors must be considered before libraries can invest in this kind of software, including:

- Budget constraints
- Patron demographics
- Staff availability
- Staff training
- Computer capabilities

To aid the selection process, then, this white paper outlines a representative sample of coding education video game products currently available organized by targeted skillset and summarizing the strengths, weaknesses, potential uses, estimated cost, target audience, and system requirements of each.

TECHNICAL THINKING SKILLS

Games included in this category do not involve typing any actual or proprietary coding languages but are designed to develop the logical and technical skills which form the foundation for the use of programming languages. The core features of these games can be used without any guidance from library staff, making them relatively low-maintenance choices.

SPACECHEM

(Zachtronics, 2016)

Retail Cost: $10 on Steam, Free for schools

Target Audience: 10+

System Requirements: Windows XP/Vista/7/8/10, Ubuntu 12.04 LTS, or Android, 2.0 GHz Processor, 1GB RAM, 300MB hard disk space, and frame buffer support

A hybrid puzzle story game, SpaceChem allows players to take the role of an Engineer synthesizing chemicals for space colonies. The game is designed to teach problem solving and programming concepts like in-order execution, loops, branching, synchronization primitives, and subroutines through the design of factory pipeline systems (Zachtronics, 2016). It also includes some basic chemistry educational elements. Over the course of the game's 53 puzzles, players are rewarded with pieces of a 10,000 word science fiction novelette, engaging users' reading ability as well as programming skills. Unfortunately, Cameron (2011) found the final puzzles to be too challenging to reach the end of the story, but he still gave the game a positive rating overall. The game is not rated, but the manufacturer estimates that the game would be rated E10 for story violence were it reviewed. If purchased directly from Zachtronics, the limited story violence may be modified or removed on request.

In a public library, SpaceChem could serve as a low-maintenance programming education resource. Its modest system requirements make it flexible for use on a variety of machines, and it is designed for children to use on their own. The inclusion of chemistry information and science fiction story may engage young people interested in those subjects as well.

MINECRAFT

Target Audience: 10+

Retail Cost: $26.95

System Requirements: Intel Pentium D or AMD Athalon 64 (K8) 2.6 GHz, 2GB RARM, Intel HD Graphics or AMD Radeon HD Graphics with OpenGL 2.1, Nvidia GeForce 9600 GT or AMD Radeon HD 2400 with OpenGL 3.1, 200MB hard disk space, and Java 6 Release 45

While not designed specifically to teach coding, the software is versatile enough that educators and librarians have begun using it to teach a variety of material (NPR). It is included in this category because on its own the game simply teaches visuospatial reasoning skills and sequential planning, and many organizations have invested in the program for these purposes. However, the base game can be further augmented through curriculum development to teach more complex coding concepts or mod building to teach coding itself. Curricula and tutorials for this are available in both free and paid forms online. Print resources such as Guthals, Foster, & Handley's *Minecraft Modding for Kids for Dummies* (2015) or Gupta & Gupta's *Minecraft Modding with Forge* (2015) are also available to expand the library collection.

The greatest strengths of Minecraft are its extant popularity among young people and its flexibility for use. Interest in the game can draw more children into library programs which utilize it, and the game can be used to teach anything from geometry to environmental science in addition to coding. The wealth of supplementary resources available from the Minecraft Education Edition site (Mojang Synergies AB, 2016) and Code.org's Minecraft Hour of Code tutorials (2016) make program planning quick and easy.

CODE-BASED GAMEPLAY

The games included in this category use coding itself as the mode of gameplay. Some games do this through more accessible, simplified coding languages proprietary to the software while others are built upon writing actual lines of JavaScript. Simplified coding language games are likely to require less assistance from on-duty staff members, while some games which use real coding languages might

necessitate patrons to be introduced to coding before beginning the game through a more structured program. As a reviewer of CodeCombat notes, however, even the lessons taught by the most direct of these games can vary in applicability to real-world coding scenarios (Minor, 2015).

Simplified Coding Languages

(Digital Dream Labs, LLC, 2016)

PUZZLETS

Target Audience: 4-12
Retail Cost: $99.99, $89.99 for educators
System Requirements: OSX 10.8 with USB port, iPad 3, iPad Mini, iPad Air, iPad Pro, iPhone 4s, or Android version 4.3 and Bluetooth 4.0 LE

Puzzlets makes programming concepts a tactile experience through a Bluetooth-enabled physical game board and command pieces which connect to games running on a secondary device (Digital Dream Labs, LLC, 2016). Focused on sequencing, the user orders command pieces on the board to complete on-screen puzzles. The image-based command system and friendly plastic pieces make it accessible to a much younger audience than most other games on the market. Most children ages 6+ can play on their own, and most children ages 4-5 can play with an older child or adult's help. A two-player mode designed to teach collaboration designates one user as Navigator, programming the play tray, and the other as Driver, controlling the on-screen functions. Educational bundles are discounted and come with an 8-Week Curriculum, Teacher's Guide, Printable Activities, and Pre & Post Assessments.

Puzzlets' younger target audience may fill a gap in library STEAM programming, and the educational bundle features make it flexible for use as an open access resource or in a more structured, librarian-led program. However, its cost is significant, especially in comparison to other available options. Additionally, the plastic pieces which make the system more engaging may also be a liability since they could easily be lost or stolen.

CODEMANCER

(Lockhart, 2016)

Retail Cost: $24.99

Target Audience: 9-14

System Requirements: Not available

Funded by a Kickstarter campaign, Codemancer is a fantasy game in which players use coding tiles called "rune stones" to navigate the landscape and battle rival sorcerers on their way to rescue the heroine Aurora's father (Lockhart, 2016). Designed to combat the cultural exclusivity of programming, the game attempts to re-contextualize programming skills in a story-based, gender-inclusive fantasy world to make the content accessible to children who would not usually have access to coding education. Unfortunately the game is still pending release, so no reviews are available.

Codemancer provides a lower-cost alternative to Puzzlets with a more complex visual coding language including "Repeat," "Repeat-If," "If," "Call," End," and "Set" commands as well as variables and true and false statements (Lockhart, 2016). Designed to serve as a Programming 101 course, the game does not require background knowledge of coding to play, meaning the game can be provided as a library resource without consuming staff time.

Real Coding Languages

CODECOMBAT

(CodeCombat, 2016)

Retail Cost: Free core levels, $9.99/mo. for full access

Target Audience: 9+

System Requirements: Chrome, Safari, Firefox, or Edge, 4GB RAM

CodeCombat is a code-based gameplay online game designed to teach children from Elementary to High School all kind of coding, including HTML, CSS, jQuery, Bootstrap, JavaScript, and Python (CodeCombat, 2016). While similar in style to Puzzlets or Codemancer, Code Combat uses real, typed code, not drag-and-drop coding blocks, from the first level of gameplay.

Because the core levels are free and accessible from a web browser, libraries only need to promote and/or link patrons to the CodeCombat site in order to provide access, although making an online account outside of a classroom does require parental permission for children under 13 (CodeCombat, 2016). Because the game is designed to teach beginners, the software does not require structured librarian-led programming, but versions designed for classroom use are available for purchase if desired.

SCREEPS

(STEAM, 2016)

Retail Cost: $14.99 on Steam, unlimited CPU $6.95/mo.

Target Audience: People with some knowledge of programming

System Requirements: Broadband Internet connection, 500 MB hard disk space

Screeps is a Massively Multiplayer Online (MMO) strategy game based on JavaScript (STEAM, 2016). Players write scripts to control colonies of "creeps": mining for resources, building units, and conquering territory. Because the gameplay is built on scripts, users' colonies remain active when the user is offline, continuing to follow the instructions they have been programmed.

While not designed to teach basic JavaScript, Screeps provides a bridge for young people to move from beginner to intermediate scripting, a demographic often overlooked in other educational coding resources. Some users found this difficulty level to be frustrating (STEAM, 2016). In a public access setting, it may be difficult to share licenses amongst many users without code being overwritten or running out the CPU limit. This does not make the game unusable, but it does limit how far a user may advance in the game to the amount of time they are able to reserve on the computer or how many users can play the game if the library does not pay a monthly subscription fee. Nevertheless, the game is a useful resource for young people who have moved beyond any other basic coding education offered at the library.

GAME BUILDING

Software in this category allows users to apply their beginner to intermediate coding skills to design their own video games, adding another level of engagement and practicality to the experience of learning to code. Generally more complex, these programs are designed for young adults. While young people can certainly make use of online self-teaching guides to these programs, game building software lends itself toward more guided library programming to support its full range of features and programming languages. Certainly not every library is equipped to offer this kind of program, but in terms of educational value, there is no replacement for the actual programming practice which these software offer.

(Enterbrain, Inc., 2016)

RPG MAKER

Retail Cost: $79.99 or less for older versions
Target Audience: 13+
System Requirements: Windows 7/8/8.1/10 or Mac OSX 10.1, Intel Core2 Duo, 2GB+ RAM, 2.5GB hard disk space, OpenGLR compatible graphics, 1280x768 screen resolution

RPG Maker is a toolset program which allows users to design and code their own 48 bit RPG game (Enterbrain, Inc., 2016). Designed to be useable by beginner coders and advanced developers alike, it includes basic plot construction tools as well as Javascript and HTML5 support. While the newest edition of RPG Maker costs about $80 per license, a significant cost for small libraries, older versions are available for as little as $19.99 per license, though they include lower output resolution and do not support touch screens. All include a wide range of features and customization, allowing young people to bring together their interests in design and storytelling with those in coding and technology.

(Bioware, 2016)

NEVERWINTER NIGHTS

Retail Cost: $8-30

Target Audience: 13+

System Requirements:

Windows 98/200/XP, Penium II 450MHz or AMD K6 450MHz or faster processor, 128MB RAM, 1.2 GB hard disk space, DirectX 8.1, 16MG TNT2-class OpenGL 1.2 compliant video card, and DirectX certified sound card or Mac OSX version 10.2.6, 450MHz G4 processer, 256MB RAM, 2.1GB hard disk space, 32MB video card

　　While not originally intended as educational software, Neverwinter Nights' included toolset feature, which runs a modified form of C and allows users to create their own RPG modules, has made it attractive for that use (Loe, 2002, p. 2; Sandford, 2008, p. 85). The fact that the game was not designed as educational software also prevents the feeling of didacticism that some explicitly educational games suffer from. The hybrid real-time turn-based gameplay and three dimensional graphics gives it a more modern feel than 48 bit builders. At the same time, this also means the system lacks somewhat the structures and supports which are standard in educational software. Notably, the game is rated T by the ESRB (Bioware Arts, Inc., 2016), which may raise concerns for some young people's parents. Moreover, while some "Plot Wizards" are included in the software, to take advantage of all its features, students would benefit from structured instruction.

Still, a plethora of user-created modules are available as free online downloads (*The Neverwinter Vault*, 2016), providing an extensive library of coding material for reference and adaptation as well as motivation for students to create and share their own game. Moreover, while no longer in print, Loe & Eastwood's *Official Neverwinter Nights World Builder Guide* (2002) overviews useful coding strategies for the game and is available used for under $10 on Amazon.

　　Released in 2002, its age may be an advantage for libraries with older computers running Windows 98/2000/XP but may present problems for those running more recent operating systems or planning to upgrade to them in the future. While the software should run in Windows' compatibility

mode feature, the notoriously finicky nature of this feature could make the software unreliable for users. The game is available for Linux/Mac but is no longer being manufactured as such, so Linux/Mac editions must be purchased from third party sellers.

CONCLUSION

Video games can be incredibly engaging educational tools, especially for teaching coding, but the best educational coding software to add to your collection will vary drastically between public libraries. Large libraries with dedicated technology staff might have the budget and resources to purchase many copies of the latest version of RPG Maker and run classes for local teenagers. Smaller libraries with only a few older computers might benefit from an investment in a lower-maintenance option like Spacechem. Libraries who want to involve more young women in STEAM activities might find that the female protagonist and fantasy story of Codemancer is more attractive to their patron demographic.

Libraries should ask (at least) the following questions before investing in educational coding software:

- How much does the software cost?
- Will our computers be able to run the game? Are we planning to update our hardware soon? Will that cause any compatibility problems?
- Will patrons need to know any coding before they play the game? Do we have the resources to teach them that?
- Is there a strong community of users or educators using the game who can provide additional resources to build on the games included features?
- Who will play this game? What game will best serve the diversity of our user population?

This white paper was designed to provide an overview of the kinds of programs currently on the market, but it is by no means exhaustive. New games are released every day, so it is impossible to provide complete coverage, but the same principles of analysis used on the games in this paper can be applied

to new programs across the market. Educators' and technology blogs can also serve as a great

resource for discovering new educational coding software which might be a good fit for your library.

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