

Digital Game Making and Game Templates Promotes Learner Engagement in Non-Computing Based Classroom Teaching

Dr Thomas Hughes-Roberts², Professor David Brown¹, Dr Helen Boulton³, Dr Andrew Burton¹, Mr Nicholas Shopland¹, Mr Jamie Tinney¹

¹ Nottingham Trent University, Clifton Lane, Nottingham, NG11 8NS
{david.brown, andrew.burton, nicholas.shopland, jamie.tinney}@ntu.ac.uk

² University of Derby, Markeaton Street, DE22 3AW
t.hughes-roberts@derby.ac.uk

³ Nottingham, UK

Abstract. This paper outlines an intervention utilising digital game making as a teaching delivery method for curriculum-based learning. Research has demonstrated that digital game making can provide a powerful means of engaging learners by leveraging the popularity of video games and can be particularly effective at engaging the unengaged, including those with learning difficulties. Past work has tended to focus on smaller scale, specific evaluations and not examined the potential of digital game making in subject based teaching in real settings. This work seeks to address this gap by defining a digital game making intervention that utilises game templates to teach United Kingdom (UK) based curriculum topics. Four schools were recruited who provided seven classes of students (N=157) to take part in the study; these included mixed ability classes and two classes comprised of learners with Special Education Needs and Disabilities (SEND). In conjunction with teachers, digital game making sessions were scaffolded around game templates. These were implemented into teaching practice to deliver a curriculum topic taught over an eight-week period. An evaluation strategy was developed that utilised a mixed methods approach to evaluate learner engagement, collaboration and inclusion across sessions. This included quantitative data captured using an in-class observation tool, and teacher interviews yielding qualitative data analysed using Thematic Analysis (TA). This paper demonstrates that digital game making can be used to teach a number of topics outside of computing. Findings from analysed data demonstrate that such approaches provide more engaging and inclusive learning experiences in the classroom.

Keywords: Digital Game Making, Educational Games, Evaluation Studies.

1 Introduction

The application of digital game making in teaching is experiencing wider adoption and implementation due to the proliferation of Visual Programming Languages (VPL); for example, Scratch (Resnick, Maloney, Monroy-Hernández, Rusk, Eastmond, Brennan, et al., 2009) and Create@School, an Android based version of Pocket Code (Slany, 2014) developed for schools (Catrobat, 2017). Such applications leverage the popularity of video games to provide learning pathways, and their multi-modal nature allows varying modes of interaction. For example, digital game making has an obvious focus on logical programming but also on asset creation. Indeed, Kangas (2009), suggests that the construction of game artefacts leads to the construction of knowledge in learners when co-creating games. Digital game making can therefore provide multiple avenues to engagement, either by developing the game itself or by designing appropriate assets for use in the game.

Game play in general can improve learning inclusion; Malinverni et al. (2016), suggests that for learners with autism, games can provide opportunity for therapeutic treatments. This is due, in part, to video games being foundational to young people's hobbies and interests and therefore it can be powerful means to stimulate curiosity for learners with special needs (Griffiths, 2002). Furthermore, work by Gabriel and Vienna (2008) suggest the introduction of game creation in school-based learning can positively influence engagement and persistence in education. This is partially due to students having a greater degree of ownership over the work gained through the development process. However, relatively little work focusses on digital game making as opposed to gameplay as a means to encourage inclusive learning, particularly for learners with Special Education Needs and Disabilities (SEND) and those learners identified as "at risk" of exclusion who are situated in mainstream education. Furthermore, digital game making can be difficult to implement, requiring specific teaching skills in programming and tailoring to the complex needs of students with a wide range of abilities. Such is the focus of this paper that presents data from a trial of digital game making using game templates delivered as a teaching intervention across a mix of primary, secondary and special schools. Game templates are specifically explored as a means of reducing barriers to access for both teachers and students as they are readily deployable frameworks for making digital games.

This paper is organised as follows. The following section outlines the benefits of using digital game making for learning and highlights the work still to be done. Next is an overview of the pedagogical implementation that uses game templates in the Create@School VPL application. An outline of the methods and data collection instruments is provided that detail the protocols followed. Quantitative data analysis examines any potential differences in digital game making sessions compared to appropriate controls and qualitative data collected from teachers further explores the intervention implementations. Conclusions and recommendations for further work are then made.

1.1 Digital Game Making and Educational Benefits

The use of VPL offer new methods of fostering learning and promoting key skills development. Past work has demonstrated that the use of languages such as Scratch can promote the development of scientific knowledge in young learners by focusing on the process of asset creation and thus making programming a “need-to-know” construct (Baytak and Land, 2011). Visual programming and game creation in Scratch has also been shown to increase a positive disposition towards mathematics in 64 students who took part in a 6-week long intervention of two VPL sessions per week (Ke, 2013).

Scratch has also been shown to be a potential means of improving problem solving skills (Kalelioglu and Gülbahar, 2014; Feskis, Gouli & Mavroudi, 2013), though these studies did not identify statistically significant results or include comparative measures. Where such measures have been used (Kalmpourtzis, 2019), there is some evidence that game creation can positively influence problem solving skills. However, such approaches require appropriate teaching interventions such as proposed and described in our work. Furthermore, Lye and Koh (2018), utilised a series of case studies demonstrating the use of Scratch is effective in teaching computational thinking in elementary school children.

A number of studies, as shown in a meta-analysis, have also focused on the role of game creation using VPL in improving engagement with, and ability in, computational and systems thinking (Werner et al., 2014). Craft-based approaches with tangible outputs can broaden participation in computing; interestingly, however, the need for scaffolding in how the challenges are structured was highlighted (Kafai et al., 2014; Silander et al., 2020). This highlights the need for structured approaches to using such techniques such as game templates. Similarly, Akcaoglu and Green (2019), demonstrated an improvement in design skills and systems analysis through a quasi-experimental approach where the treatment utilised game design techniques. Similarly, Bulut et al., (2022) utilised a pre-and-post-test measure of creativity to observe the effect of educational game design on young learners. Findings suggest improvements in general creative thinking ability. This was focussed on game design itself and not as part of any particular curriculum-based teaching activity.

While these studies demonstrate the transferable skills in computational thinking that can be developed using digital game making, we ask if such techniques can foster the development of curriculum centred knowledge found outside of computing programmes of study and what should such approaches look like?

Where groups at risk of exclusion are concerned, improvements in computational thinking for students on the autism spectrum when using a Scratch based intervention were observed (Munoz, Villarroel, Barcelos, Riquelme, Quezada, & Bustos-Valenzuela, 2018). Furthermore, research has demonstrated that collaborative game design can improve digital competencies in both in and out of school activities (Laakso, Korhonen & Hakkarainen, 2021). This can also provide learners with an opportunity to take differing perspectives from their own during the design process if instruction is appropriately scaffolded (Dishon and Kafai, 2020). While Denner (2011), found that not only did game creation positively influence computational thinking but was particularly effective for female learners who typically experience exclusion in such sessions.

This is mirrored in work by Fisher and Jenson (2017), who suggest that game making reduces barriers for girls to education as they gain tangible ownership over their learning through construction of their own subjectivities, thus promoting engagement.

Hence, several works promote the power of game making in encouraging engagement for learners that may be seen as at risk of exclusion.

Indeed, digital game making using VPL has been highlighted as a means of “engaging the unengaged” (Thumlert, de Castell & Jenson, 2018), through its use of a production pedagogy that enables students to learn through the process of creating artefacts and assets that have value to them as individuals. Maloney et al. (2008), for example, found that the Scratch’s simplified, multimedia-based approach was effective in increasing engagement in programming for urban youth. Where SEND learners are concerned, engagement is noted as the single most important indicator of learning (Iovannone, Dunlap, Huber & Kincaid, 2003) and has been used as a measure for assessing teaching impact for SEND learners in related work (Hughes-Roberts et al., 2019).

Such constructionist approaches allow learners to better connect to each other and address issues of access. It is also suggested that the focus of research should be on the role of collaboration in the game making process as opposed to examining only the benefits to learning coding (Kafai and Burke, 2015). It is suggested that digital game making can create a more collaborative learning environment that better connects learners through shared interests. Furthermore, there is evidence that learners with SEND can improve their social skills when utilising digital game making, as observed in an 8-week study with autistic students engaging with Scratch (Eiselt and Carter, 2018). Meishar-Tal and Kesler (2021), suggest that improvements can be made across a number of learning skills including cognitive and emotional skills when using tools that generate games for learning. However, as noted by the authors, this small-scale study requires further case studies and interventions to confirm their findings.

The potential benefits of digital game making appear to be well presented in research. However, research prioritising a long-term perspective, and which examines the benefits of digital game making in achieving curriculum learning objectives across a variety of subjects outside of STEM is lacking. Indeed, it has been noted that past studies often have a lack of clarity in their methods and require a longer-term application in their interventions (Standen & Brown, 2014; Denner et al., 2019). Furthermore, typical classrooms are often made up of cohorts of mixed abilities, including students classified as at risk of exclusion due to their individual learning needs. Given that digital game making has been used to engage the unengaged, it may also be well-suited to improving inclusion with learning for students with SEND. As pointed out by Meishar-Tal and Kesler (2021), studies tend to focus on improving computational skills and more work is required that generalises game making across a variety of subjects in school learning and does so through a longitudinal intervention-based trial.

Past work (Hughes-Roberts et al., 2020; Boulton et al., 2020) has provided some demonstration of the promise that digital game making holds for classroom teaching in lessons outside of computer science or information technology. Here, digital game making was implemented within lessons focussed on history and life skills, and findings suggested that this approach was at least as engaging as traditional teaching methods and, in some cases, more engaging while fostering greater opportunity for

collaboration. However, this pilot study lacked longitudinal approaches across more diverse test centres and suggested the need for formally defined templates that allow focus on a range of curriculum subjects rather than primarily learning to program.

There is a need, therefore, for a longitudinal trial of digital game making within classroom teaching in order to validate the apparent benefits it provides. Furthermore, given the complex nature of digital game making from a skills-based perspective, sound pedagogical designs and learning approaches are required that enable its deployment across a range of curriculum subjects.

Applications such as Create@School provide opportunity for developing such techniques. Create@School offers a simple to use VPL designed to facilitate digital game making. Its availability on the Android platform affords a low barrier to entry for schools (Catrobat, 2017). Furthermore, it allows integration of pre-made game templates which can scaffold activities based on teacher requirements as noted as important in the literature. Game templates allow the focus to be maintained on the content and learning material, while still utilising the benefits of a digital game making teaching method (Speiler et al., 2018; Hughes-Roberts et al., 2020). They also provide a means of scaffolding sessions, making the created games “objects to think with” (Dishon and Kafai, 2020). Furthermore, these templates also improve access for teachers, particularly for those without the necessary skillset to implement or troubleshoot the more advanced game programming concepts. Related work using Create@School mirrors these results where evaluation of its use has found increases in student creativity and enthusiasm for learning (Spieler et al., 2018).

1.2 Research Aims

This study aims to evaluate digital game making in both special education and inclusive classrooms using game templates to scaffold the activities of students with learning disabilities. A within-subjects experimental design is utilised that deploys digital game making as a teaching intervention. In this design, baseline measures are taken from normal curriculum-based teaching and compared to curriculum-based teaching that uses game templates to scaffold digital game making activities. This study therefore explores the following research questions:

RQ1. What is the impact on learners when utilising digital game making and game templates, and what impact can it have on fostering an inclusive classroom? This paper proposes a novel teaching framework utilising digital game making and game templates. Related work suggests that digital game making can improve engagement for learners at risk of exclusion and promote collaboration through shared interests. Therefore, this research sees engagement and collaboration as indicators of inclusive learning, and we seek to validate wider research findings through a full trial exploration.

RQ2. What are the outcomes, benefits and challenges to using such approaches in classroom teaching? As well as deploying a longitudinal trial, there is a need to evaluate digital game making using a mixed-methods approach to provide rich recommendations for its use in the real world. As such, teachers form part of our group of participants and are asked to take part in qualitative data collection sessions.

This study differs from others in its implementation of the intervention within real classroom settings taking the place of real curriculum-based teaching outside of computing-oriented subjects. All students across each site therefore experience typical curriculum teaching and then suitably comparable sessions delivering curriculum-based teaching with digital game making.

This study formed part of the Horizon 2020 (No 645215) project No One Left Behind which “sought to allow children to use a non-leisure gaming ‘toolkit’ to develop digital games on mobile devices – with the aim of enhancing their abilities across all academic subjects, as well as their logical reasoning, creativity and social skills” (No One Left Behind, 2017).

2 Research Model

As pointed out in the literature, there is a need for full trial interventions of digital game making in teaching to validate research results. As such, a mixed method approach was deployed consisting of a longitudinal trial where digital game making techniques scaffolded teaching sessions. Quantitative data was collected through in-classroom observations and qualitative data collected from participating teachers at the trial conclusion using semi-structured interviews and thematic analysis.

The study utilised the Create@School visual programming environment, an enhanced and accessible version of Pocket Code tailored to the educational domain within the EU H2020 No One Left Behind project (Catrobat, 2017). This version added an implementation of the Global Public Inclusive Infrastructure (GPII) which allowed a degree of personalisation. For example, allowing accessibility for students with special educational needs, such as bigger sizes of text for easier reading, the use of symbols as an alternative to text, appropriate colours and contrast for those with visual impairments. This was designed following an extensive evaluation of the software within an educational setting (Gaeta et al., 2019). A suitable curriculum topic was selected by teachers and a module of teaching material using Create@School was co-designed with them. The module of teaching took place over the course of a school term of around 8 weeks. This included the development of individual lesson templates incorporating the previously developed game templates to achieve session learning outcomes. Game templates were used to structure the sessions. These provided teachers with accessible teaching material, so sessions would not have to be created from scratch, nor require more than basic programming knowledge. Furthermore, the templates allowed learners to focus on content creation, whilst preventing the complexity of game programming concepts from becoming a barrier to the inclusion students with a range of cognitive impairments.

Sessions were delivered by the usual class teacher supported by a researcher trained in the use of Create@School. A research assistant was also in both control and intervention sessions, carrying out data collection through observation.

2.1 Outcome Measures

Outcome measures included engagement and collaboration, where data was gathered through direct observation during real teaching sessions, and via interviews with teachers at the end of the study. As such, methods were derived that affected these sessions as little as possible and were as unobtrusive as possible. An observation protocol provided a means for recording learner state based on seven observable behaviours. Broadly, these behaviours represented a state of off-task (not engaged), on-task (engaged) and on-task with others (collaborating); examples of such behaviour which guided the observer are found in table 3 below. This tool was built on the observation tool developed in Hughes-Roberts et al., (2020) which was modified from the STROBE classroom observation tool (O'Malley, Moran, Haidet, Seidel, Schneider, Morgan et al., 2003). A trained research assistant sat in all intervention and control sessions and using a time sampling technique coded the observable student behaviour; this is outlined in detail later in the paper.

To validate the observation data and to add to the emerging learning behaviours that cannot be easily quantified, a semi-structured interview was used with subsequent thematic analysis.

2.2 Procedure

Prior to the start of the study teachers attended a training session in the use of Create@School including using the App to facilitate digital game making in the intervention sessions and a grounding in basic programming concepts for those unfamiliar. A summary of courses, topics and accompanying game templates can be found in table 1. Following the training, teachers selected appropriate modules of teaching that would suit the implementation of digital game making as a teaching method. A timetable for the sessions was devised that fitted with each school's typical teaching expectations. Each session was designed using a suitable game template with the focus on the learning objectives that would otherwise have been taught for that module of curriculum content. The sessions took place over a normal school teaching term and consisted of up to eight, one-hour classroom sessions taking place once per week. In instances where the module of teaching required less time, fewer intervention sessions were utilised. Teachers proposed suitable control conditions from sessions that were available in the teaching timetable. Identification of controls was based on the similarity of the learning objectives and teaching methods to proposed intervention sessions. The measurement for the control sessions were taken prior to the intervention sessions being carried out. Each class provided their own control teaching sessions for comparison with the intervention sessions using game templates.

We do not compare amongst classes across the different test centres due to the inherent variability in learner characteristics (see Table 2).

Table 1. – Test Centre Session Overview

School	Topic	Course	Game Template
--------	-------	--------	---------------

Centre 1a	Anglo-Sax- ons	History	Quiz
Centre 1b	Space	Science	Adventure
Centre 1c	Food from around the world	Geography	Puzzle
Centre 2a	Work and Life skills	Work and life skills, literacy, IT	Adventure
Centre 2b	Work and Life skills	Work and life skills, IT	Adventure
Centre 3	Atoms, ele- ments and compounds, energy	Science	Action
Centre 4	Life cycles	Geography	Action

An example intervention session for Centre 1a would include a game template containing a single scene and the programming logic for one multiple choice quiz question with answers represented by appropriate media (images, sounds etc.). Following some didactic content delivery on the topic, learners would complete the quiz by compiling appropriate questions and content. Those comfortable in doing so could then expand the program by adding more scenes and gamified elements, e.g. scores, timers and so on. An equivalent control session would mimic the process but using paper and pencil derivatives for content production as the students would typically. To provide a further example, the adventure template would provide a scene of a story which can be expanded with content that adds characters, scene assets, narrative choices etc. An equivalent control included a derivative of the process, using storyboarding techniques akin to creating comic strips.

The project was fully ethically approved by the Nottingham Trent University Joint Inter College Ethics Committee and parental consent gained from each participant. Participating teachers also signed their consent to their project involvement including data gathering from interviews. Each session was attended and observed by a trained researcher where the observation protocol was utilised to determine participant engagement through the time sampling method.

2.3 Research Context

A number of schools provided case studies for the intervention implementation. Case studies followed a within-subjects experiment design where typical teaching sessions were observed as controls to gain baseline measures of engagement and collaboration for later comparison to intervention-based sessions using the same participants. Session learning outcomes and lesson plans were co-developed with the teacher responsible for each class of participants. Teachers were also asked to identify appropriate sessions to

utilise as control conditions where learning outcomes and level of challenge matched the intended intervention sessions. All sessions were delivered by the teacher as usual; intervention sessions were co-delivered alongside a trained researcher versed in digital game making using the Create@School App. Each session was observed on site by an evaluation researcher who gathered quantitative measures of engagement and collaboration to evaluate research question 1. Following the trials, semi-structured interviews were utilised to gather data on the use of digital game making as an inclusive teaching tool and to capture nuanced data on issues such as other learner outcomes that were not quantified through the observation protocol (research question 2).

Participants were recruited from four schools within the UK: two primary schools, one special education school and one secondary school. One of the primary schools and the special education school provided several year groups. These sites were chosen as they provided participants that matched the target profile of the study as all schools contained classes of mixed ability students with several identified as at risk from exclusion. The special education school, in particular, provides for needs of children and young people who have severe, profound and complex learning and physical difficulties and disabilities. Certain pupils may also have associated needs in the areas of emotional/social and communication and interaction such as autistic spectrum disorder and/or speech and language difficulties. These are always in addition to the primary learning need. The study design, where the participants acted as their own control, accounted for the heterogeneous nature of the sample where a paired control would be difficult to identify and achieve, and highlighted as an appropriate experimental design in technology related projects involving such pupils (Hughes-Roberts et al., 2019).

2.4 Research Sample and Participants' Detail

Participation was voluntary and teachers nominated specific classes to take part in the study to meet the inclusion criteria for the study. Participants within each class fell within the age range defined by their year group and each class catered for a range of abilities typical for the school and age range. Full details of participants can be found in table 2.

Table 2. – Participant Overview

Test Centre (anon)	Year Group	Students	School Category	Learner Characteristics
Centre 1a	Yr 6	30	Primary	Mixed Ability, including students: with moderate learning disabilities, with low literacy levels
Centre 1b	Yr 5	30	Primary	Mixed Ability, including students: with moderate learning disabilities, with low literacy levels

Centre 1c	Yr 4	30	Primary	Mixed Ability, including students: with moderate learning disabilities, with low literacy levels
Centre 2a	Yr 11	12	Special	All students have severe learning disabilities
Centre 2b	Yr 12	5	Special	All students have severe learning disabilities
Centre 3	Yr 8	27	Secondary	Mixed Ability, including students: on SEN register, with low literacy levels, with below average cognitive test scores
Centre 4	Yr 5	23	Primary	Mixed Ability, including students: on the SEN register, with moderate learning disabilities, on the autistic spectrum

Note for mixed ability classrooms, around half of the class would be at a below average learner level for their age group either due to the reasons outlined in the table or their general cognitive development.

2.5 Instruments

The observation protocol was based on the STROBE classroom observation tool (O'Malley et al., 2003; Kelly, Haidet, Schneider, Searle, Seidel & Richards, 2005) which sought to capture target behaviour over fixed intervals (Alessi, 1980). Using this tool, a trained researcher selects a participant from the sample population and over a twenty-second window observes their behaviour. The behaviour exhibited at the end of the window is then recorded using the behaviour codes found in table 3. This momentary time sampling technique was chosen, as it is more likely to capture changes in behaviour compared to partial sampling (Rapp, Colby-Dirksen, Michalski, Carroll & Lindenberg, 2008), where the behaviour simply has to be observed at any point during the sampling window. Partial sampling is not suitable for this study as engagement should be a persistent behaviour. This process was repeated every five-minutes for the duration of the session; and each five-minute window included a sample of five participants. Other behavioural measures were taken concerning the teacher behaviour and overall class behaviour.

Table 3. – Behavioural Observation Codes

Code	Learner Behaviour
------	-------------------

1	Off-task – engaged with another behaviour e.g., looking at phone or other material.
2	Off-task – disruptive to peer or peers.
3	Reading, writing, typing, listening – could be following the session but difficult to determine, could be waiting for the next instruction.
4	Following along with instructor or with learning material – e.g., off slides, from a book, in response to a request for help etc.
5	Receiving personal tutoring or interacting with teacher; demonstrating work to them etc.
6	Demonstrating work to another student. Receiving demonstration from a peer.
7	Working with another student or groups of peers to solve problems.
8	Wanting to participate/speak/demonstrate (arm raised) or actively participating – answering questions or demonstrating work to the class.

Data from the 8-point behaviour scale was then recoded to determine broader instances of engagement and collaboration; for example, codes 1-2 demonstrate no engagement, any other code engaged (3-8), and codes 6-8 engaged with collaboration. After all sessions had been observed and coded using the observation protocol, the Statistics Package for Social Sciences 20 (SPSS) was then utilised for further analysis. As noted, this approach was developed during piloting phases of the study, details of which can be found in a separate publication (Hughes-Roberts et al., 2020).

It should be noted that a limitation of this approach is the potential to under-represent behaviours where behaviour is shorter than the observation window (Ary and Suen, 1983). As stated, however, learning behaviour, specifically engaged and collaborative behaviours, should not have this issue as they represent persistent, longer lasting states.

At the end of the testing cycle, each participating teacher took part in a semi-structured interview; focus groups were used in schools that had several participating teachers. Interviews were recorded and transcribed verbatim following the sessions. Thematic analysis (Braun and Clarke, 2006) was used to analyse the interview data to determine emerging themes. The interview sought to explore the following issues with particular relation to RQ2:

- Teachers' perceptions of digital game making in their teaching sessions.
- Student learning outcomes that the quantitative observation protocol could not capture.
- Any potential barriers or facilitators to the widespread adoption of digital game making in traditional curriculum-based teaching.

The full interview protocol can be found in the appendix.

2.6 Create@School and Design of Game Templates

Create@School is derived from a pre-design version known as Pocket Code which added enhanced accessibility features and is available from the Google Play store. As with any VPL, the interface defines a series of pre-defined bricks that represent modules

of code which, when joined together create a complex program. Through the use of game templates, students can focus on asset creation to design simple games or animated stories, or use traditional programming concepts to create fully fledged games and mechanics. This flexibility allows learners of varying skill to engage with the session. A companion application, Pocket Paint, allows the creation of assets and ensures game templates are easily integrated and shared amongst users.

Several studies previously discussed highlighted the importance of asset creation in improving subject knowledge in learners when engaging with digital game making. It is vital that the complexities of programming do not get in the way of this process, particularly for low ability students who may become disengaged with sessions when faced with too much complexity. An evaluation of Scratch's usability for students with SEND demonstrated barriers to engagement, where some of the more abstract concepts were beyond the understanding of such students (Zubair et al., 2018). To overcome these barriers this project developed a series of pre-made game templates to structure sessions whilst retaining focus on subject learning required in the curriculum. Furthermore, these templates scaffold the digital game making activities for the lower ability students who are not yet able to fully engage with the required programming concepts.

This study utilised four game templates to structure the digital game making sessions chosen by teachers for the intervention. A typical intervention session would involve students developing a game using these templates, to scaffold their game making activities depending on their level of skill and ability. By the end of the course of the intervention sessions, students will have created a game demonstrating their level of learning and understanding for that topic. The templates are designed to enable "enhancements by users", which detail the minimum additions that can be added or edited towards the development of a full game. More competent learners can, however, modify any element of the template, from the addition of assets through to the manipulation of game mechanics should they be able to. Their use outlines a dynamic, flexible and potentially more inclusive means of engaging with non-computing related content.

Figure 1 illustrates the first of these templates, a multiple-choice quiz game. Here students can modify the template by adding content to questions in terms of assets and modifying the logic to increase the number of questions.

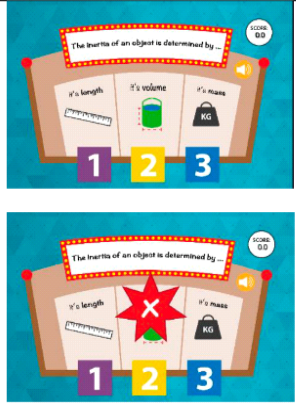
	Create@School game created:	Quiz
	ID: 9992	
Description:	Question/answer with text and images (audio). Provide content per the questions.	
Gameplay:	Tap on one of the answers (1, 2 or 3). After answering the question, you get additional content. Switch to the next question by tapping.	
Enhancements by users:	Add looks and more questions.	
Learning goal:	Define questions to a certain subject/topic.	

Fig. 1. - Quiz Game Template

Figure 2 illustrates the adventure game template. Here, asset creation can focus on narrative elements including additional sound files and additional levels defined through modifying the programming logic.

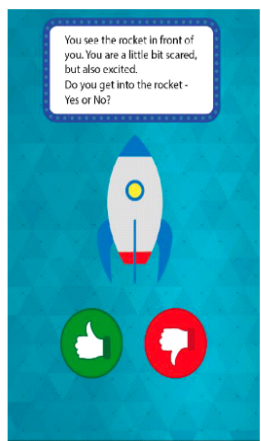
	Create@School game created:	Adventure
	ID: 9995	
Description:	Storytelling with linear choices.	
Gameplay:	Listen to a question and decide "Yes" or "No". It is a linear game so one question will also lead you to the end of the game.	
Enhancements by users:	Add content and sound files. Define more levels.	
Learning goal:	For retelling a book. E.g. Help the characters to escape to a safe place (refugee stories) or answer subject related questions during the adventure.	

Fig. 2. Adventure Game Template

Figure 3 outlines the puzzle template allowing learners to add additional puzzles and game elements (scoring, timers etc.) as well as adding relevant subject content.

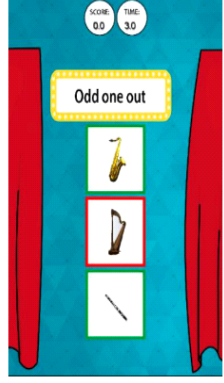
	Create@School game created: Puzzle
	ID: 10148
	Description: Odd one out, skill game.
	Gameplay: Tap on the curtains to open them. Tap on the one icon that does not fit with the others (odd one out). Attention: Time is running out – you only have 3 seconds to choose, or your score will decrease!
	Enhancements by users: Add looks and adjust the code.
	Learning goal: Logic challenge. Learn about a topic.

Fig. 3. - Puzzle Game Template

Finally, the action game template (Figure 4) provides a more traditional game-based mechanic to collect the correct objects relevant to the subject being delivered. Students can add additional objects and modify game objectives.

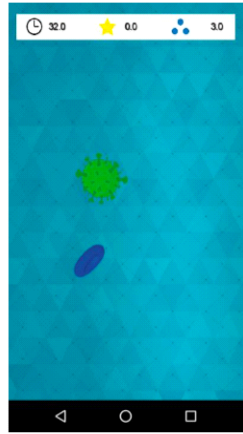
	Create@School game created: Action
	ID: 9997
	Description: Tap on screen and get points per the asked question. Attention: Objects can also reduce the score.
	Gameplay: Tap on correct objects. The correct/incorrect objects depend on the question. The HUD-elements also include a timer with 30 seconds, a high score display and your current score.
	Enhancements by users: Add correct and incorrect objects. Define an overall question.
	Learning goal: Learn about a certain topic e.g. deoxygenated and oxygenated blood cells by tapping on the objects.

Fig. 4. - Action Game Template

2.7 Data Analysis

Data were analysed using SPSS 20. The observed behaviours were re-coded to gain broader learner states of off-task, on-task and collaborating. As this data is nominal, a Chi-Square test was used to evaluate for difference to the control sessions, i.e. are significantly more engaged states observed in intervention sessions compared to the control? Each test site's intervention sessions are compared to that group's control sessions. All quantitative data are expressed as a percentage value of session length due to variation in session length (all around 1 hour).

Interview transcripts were analysed for emerging themes using a thematic approach to qualitative analysis; a number of themes were identified for further exploration.

3 Results Summary

Following the completion of the testing cycle, the number of intervals and student observations were summarised and can be found in table 4. There were 603 observation intervals spread across 48 intervention-teaching sessions. This provided 2,022 individual student observations. For comparison with the controls, there were 595 discrete student observations to provide comparison data for each class. Data is only analysed per test site and not as a complete group due to the inherent variation in age ranges and learning needs between different classes in different schools.

Table 4. - Data Collection Overview

	Centre 1a	Centre 1b	Centre 1c	Centre 2a	Centre 2b	Centre 3	Centre 4
Intervention Sessions	8	8	5	7	8	7	5
Intervention Intervals	131	122	54	75	100	63	58
Intervention student observations	486	447	235	269	357	242	204
Control Sessions	2	1	2	2	2	2	1
Control Intervals	28	16	24	24	18	23	13
Control student observations	109	64	120	86	72	92	52

3.1 Results: Impact on Engagement

The total percentage of observed behaviours for engagement are summarised in table 5. Results show, for example, that in test site 1a, 90.1% of observed behaviours can be

classed as engaged, as a summary of all intervention sessions. For all test sites bar one of the special school classes, there is a significant difference when comparing intervention sessions to control sessions using a Chi-Square test for association.

Table 5. - Engagement Data Statistical Analysis

	Intervention		Control		Chi-Square Value
	En-gaged	Not en-gaged	En-gaged	Not en-gaged	
Centre 1a	90.1%	9.9%	73.2%	26.8%	P<0.0001
Centre 1b	87.5%	12.5%	78.1%	21.9%	P=0.042
Centre 1c	95.1%	4.9%	81.5%	18.5%	P<0.0001
Centre 2a	80.3%	19.7%	72.1%	27.9%	P=0.108
Centre 2b	89.6%	10.4%	75%	25%	P=0.001
Centre 3	82.2%	17.8%	70%	30%	P=0.015
Centre 4	93.6%	6.4%	82.7%	17.3%	P=0.012

3.2 Results: Impact on Collaboration

A summary of observed collaborative states can be found in table 6. Unlike the engagement data, only two groups exhibited significant differences when compared to their control sessions: Test Centre 2b in the special education school and Centre 3 in primary education school.

Table 6. - Collaborative Data Statistical Analysis

	Intervention		Control		Chi-Square Value
	Collab'	Not-Collab'	Col-lab'	Not-Collab'	
Centre 1a	14.3%	85.7%	13.4%	86.6%	P=0.794
Centre 1b	16.6%	83.4%	20.3%	79.7%	P=0.454
Centre 1c	11.9%	88.1%	6.5%	93.5%	P=0.151
Centre 2a	4.1%	95.9%	3.5%	95.6%	P=0.794

Centre 2b	9.8%	90.2%	0%	100%	P=0.006
Centre 3	16.9%	83.1%	0%	100%	P<0.0001
Centre 4	21.1%	78.9%	21.2%	78.8%	P=0.991

3.3 Results: Summary of Themes from Teacher Interviews

Following the trial, three qualitative data gathering sessions took place; one for each test centre other than centre 4, where a subsequent interview could not be organised due to conflicts with the school's timetable. Where multiple teachers were involved in a single test centre, a focus group was used instead of the one-to-one interview but using the same protocol.

Thematic analysis of the interviews/focus groups produced six emerging themes. Themes were informed by the previous literature review which dealt with concepts of engagement, collaboration, inclusion and accessibility. Furthermore, data analysis was informed by previous work which suggested further exploration of these areas as warranted (Hughes-Roberts et al., 2020). -These themes are summarised in table 7.

Table 7. - Interview Themes

Themes	Description
Engagement	Dealing with the level of learner engagement/focus within classroom sessions and in other sessions as a result of the project.
Inclusive Classroom/Collaboration	Dealing with the degree to which the class as a whole provides an inclusive environment for learning through improved peer interactions.
Inclusive Classroom/Individual Learning	Dealing with changes to individual participants that enable them to better engage with their learning within the classroom or beyond.
Knowledge and Skill acquisition	Dealing with the ways in which Create@School enabled or perhaps improved a learner's ability to gain new subject knowledge or skills.
Accessibility	Dealing with the ways in which Create@School overcomes issues with usability and accessibility.
Barriers	Dealing with the potential issues preventing the long-term use of Create@School within everyday teaching and learning.

These themes and the data that produced them are used as the basis for structuring the following analytical discussion.

4 Analysis and Discussion

The observation data suggest benefits for student learning when using game templates as part of digital game making. All classes, except one, demonstrated significant differences in engagement with a greater number of instances of engaged behaviour in intervention groups. Two classes showed significant differences in collaboration and others held no significant difference suggesting that digital game making is at least as effective in encouraging collaboration as traditional methods. This would agree with wider research which suggests making games better connects learners to each other thereby fostering collaboration (Kafai and Burke, 2015; Uğraş et al., 2022). This result is also likely to be more heavily influenced by the teaching techniques employed in each session than engagement is, i.e., there is less scope to foster collaborative behaviours when utilising certain teaching templates.

The interview data is therefore used to explore these results further, shedding light on the findings from the observations and expanding on emerging findings from these data. As such, the themes that emerged as part of the qualitative analysis are used to structure the following discussion of the study's outcomes. Selected quotes are used to illustrate each theme as a basis for discussion of issues pertinent to each test centre, (Cn to indicate test centre, and a teacher code Tn).

4.1 Engagement

The teachers' perceptions appear in line with the quantitative data, namely that the digital game making sessions increased engagement observed in learners for the most part. This validates the wider research explored in the literature review that suggested some of the positive outcomes game making can have for learners, e.g., Breien and Wasson (2021). Teachers across test centres noted:

“They are very engaged in it aren't they? They are desperate to get the tablets out and do work on them” [C1, T2] and “They are all really keen. Sometimes we have to say, “put your tablets on the table and listen a minute”, because they all want to get on with it. But it's really lovely to see though, because in other sessions, I'm going “come on, let's get on with our work”” [C2, T1]. Note, this latter quote deals directly with the class (students with severe learning disabilities) that did not hold significantly different engagement compared to their control session. Teachers' feedback here would suggest that their students exhibited a more engaged attitude; hence, this discrepancy in statistical outcomes may be due to the observation tool not being sufficiently nuanced to be able to capture more intangible behavioural outcomes, for example, general attitude and learner persistence. Indeed, it may be harder for evaluation researchers to classify the engagement states of students with severe learning disabilities compared with classifying the corresponding states of students with special education needs. It is plausible that students with severe ID may appear disengaged based on behavioural definitions yet be cognitively or emotionally engaged. For example, a student may not be able to physically interact with materials but be processing the information and enjoying the learning activity (Hollingshead, Carnahan, Lowrey & Snyder, 2017 in Hollingshead, Williamson and Carnahan, 2018).

However, teachers did note the importance of using an appropriate game template in relation to the learning goals of the session in ensuring an engaging learning experience:

“There was a game where you had to bounce from level to level, which was pretty good because it actually felt like a game, which is what they wanted. Whereas they’ve had other ones where they’ve just had to add photos to a slideshow kind of thing. I think there were less into that because it felt less like a game, more like a piece of work” [C3, T1].

The importance of asset creation as a learning activity has been highlighted earlier. However, this would suggest that the tangible game outcomes are more successful in encouraging engagement when they exhibit traditional game mechanics. As noted in the literature review earlier, engagement is important in fostering further learning particularly for students who are at risk of exclusion due to their individual learning needs. The idea of play is central to this for such students (Lombardi, 2022), results here suggest that engagement is encouraged through the game design process and rewarded through something to play with at the end. Again, engagement is the single most important indicator of learning where SEND students are concerned and is therefore essential in inclusive teaching/learning as it is the first step to deeper learning (Iovannone et al., 2003).

4.2 Inclusive Classroom/Collaboration

While the observation data suggested improvements in collaborative behaviour in two test sites, the teachers’ perceptions support the use of digital game making in encouraging flexible learning, which can be collaborative:

“I think it is really good in showcasing their work, because they want to show each other what they know” and “they tend to go to each other before they go to the adults in the room. To try problem solving and debug their program” [C1, T2].

For students who are of a higher ability, digital game making gives an opportunity for peer support by asking them to tutor their co-learners:

“Today I was getting him to explain to the other students how to do something so that he wasn’t on his other games, so that he was doing something productive in the session” [C2, T2].

These perceptions would suggest that the observation protocol may not be granular enough to identify more complex student interactions and appropriate mixed method approaches are more suitable for measuring subjective learning benefits. However, the broad teacher observations are in line with those found in related work (e.g., Meisher-Tal and Kesler, 2021) where such results were also found in the action research derived from teacher diaries.

4.3 Inclusive Classroom/Individual Learning

As well as apparent impact at a classroom level, teachers noted that digital game making appeared to influence a number of students on an individual level, which included their general attitude and the approach to learning. This is in line with research suggesting that such approaches can engage the unengaged (Thumlert, et al., 2018). As

mentioned in the student characteristics in table 1, the test centres used in this study were mixed ability with a number of students exhibiting challenging learning needs. It was on these students that teachers perceived the most surprising effect:

“[Name redacted], he tends to struggle to hold his attention in a lot of lessons. But this is something he has really excelled at” [C1, T2] and “I barely get him to do any work, yet he will sit there, and won’t get out his seat. And that is the thing with him, he’ll constantly get out his seat looking for distractions. Yeah, he’s just sat there focused, getting on and actually he’s one of the lowest abilities in the class and yet he’s still doing the things” [C2, T1].

It appears that more students are not only able to engage with their learning but also exhibit improved behaviour, and as such wider inclusion is more likely throughout the cohort. Rangvid (2018), presents empirical evidence that to be properly included in school, it is not sufficient that students are placed in class with their regular peers – to learn at their best they must be engaged.

Interestingly, teachers reject the notion that such change may be due to the device rather than the software:

“That’s not just the tablet, that must be Create@School, because we tried him with typing on the tablet and other work on the tablet which didn’t go particularly well. So, it is a lot because of Create@School that he’s doing during those lessons” [C2, T1].

Similarly, in the test centres 2a and b, the participating teachers attempted a paper-based version of the game and noted:

“He was not engaged and finding it quite tricky to look and decide what it is exactly he was doing. Then we put an iPad [sic] in front of him, he was really engaged at looking at the board and waiting and really engaged by what’s happening and he was matching it straight away” [C2, T1].

4.4 Knowledge and Skill Acquisition

Teachers noted that the use of digital game making not only allowed a greater focus on the learning material by embedding it into the game templates, but also promoted computational thinking skills through programming for the higher ability learners. This again validates wider research, (e.g., Lye and Koh, 2018; Durak and Güyer, 2022), and builds on this by offering a flexible means of deploying such techniques through the use of game templates.

“... what’s great about that from a teaching point of view is that you have got all the right subject matter in there. You are actually showing that a lot more than you might in a writing task” and “I think actually they are taking coding to an incredibly advanced level, aren’t they? Some of the things they are doing are well beyond what ever I’d expected them to do in primary school” [C1, T1].

The game-based nature of the work appeared to provide context that encouraged understanding of what teachers usually see as quite advanced skill sets:

“These students are generally quite weak academically, yet they have a certain degree of computational thinking or creativity where they can just do things so quickly” [C3, T2].

It has been noted that game design can often allow students to “think through” games about the subject matter at hand, even when they have little design or academic background (Glas, Vught and Werning, 2022). However, the importance of appropriate game templates that provide a balance between subject focus and programming skill is highlighted; otherwise, there is the possibility of too much time spent on developing computational skills:

“But that is more they’ve learned how to program more than they have Science, I’d say” [C3, S1].

4.5 Accessibility

Given the target population for this study, students of mixed ability, including those with moderate and severe learning disabilities, autism, and those on the SEND register, it was important that the implementation strategy encouraged an inclusive classroom. The software therefore had to be accessible, and the game templates were created to provide pathways that cater for the variation in the sample. To an extent, this seems to have been provided with the increased engagement observed in the intervention sessions. Indeed, teachers stated:

“And it doesn’t require handwriting which is a thing he really struggles with. It is nice to see him grow in confidence because of that” [C1, T3].

Furthermore, the teaching and learning approach described offers something even for students who struggle:

“... I think she has found it really difficult. I’m sure she enjoys it, but is not able to access it, apart from the drawings, she really likes the drawing” [C1, T2].

Although, the student appeared to struggle with the material and sessions aims, there was still aspects that she was able to engage in which otherwise would not be evident in the session.

Similarly, the dynamic content presentation styles allow learners to approach interaction in a way that suits their level of understanding:

“Things like you know when you get to this screen here [shows tablet] having different colours, because sometimes if you could say “click on the purple ‘explore button” it is easier than saying “click on ‘explore”” because a lot of them can’t read” [C3, T1].

Here, the colour coding of the programming blocks provides a layer of instruction that suits students at the lower levels of ability and allows engagement with the session. It would appear that the described pedagogical approach provides a multi-modal teaching activity. This approach is easily scalable to the cognitive level of the learner without wholesale changes to the overall session outline. Individuals in mixed ability classes can therefore engage with the elements that suit them, and still gain from the sessions that otherwise may have excluded them.

4.6 Barriers to Long Term Use

Finally, teachers highlighted a number of potential barriers to wide-scale adoption and long-term use of digital game making as an everyday mode of teaching. Specifically,

the level of programming knowledge to design and troubleshoot sessions was of the most concern:

“Whilst I would say that I am digitally literate, when it comes to using specific programming tools I just get lost in the ether. It can become quite frustrating” [C3, T1].

Technical difficulties are a well observed aspect where game design techniques in the classroom are concerned (Durak and Güyer, 2022). The developed game templates were an attempt to address this barrier. They offered a framework of pre-existing code that required only assets to be created that aligned with the teaching topic being implemented. Only minor changes in logic were needed to add more questions or additional levels to the games being made. Teachers did highlight the effectiveness of these templates and suggested that a larger bank of pre-made templates would be required going forward:

“...could almost do with like a catalogue of simple programs, and three or four different ideas of activities that could accompany those” [C1, T1].

As mentioned earlier, templates allow the focus to be on course topics as students can tailor the content to suit. This gives them ownership of a tangible learning outcome and provides avenues for further work for the higher ability students:

“... so that the stuff the kids did were basically add-ons or added their own photos to it or adding their own levels to it, or whatever, like their own points scoring” [C3, T3].

5 Conclusions

This paper represents a comprehensive review of digital game making that is grounded within everyday classroom teaching across multiple school types. In relation to the research aims outlined earlier, digital game making utilising game templates provides an engaging teaching and learning experience for mixed ability and special education classrooms. We have outlined a novel approach to deploying such teaching methods within subjects which are not computing focused and provided validation for its use through a mixed methods trial.

RQ1. What is the impact on learners when utilising digital game making and game templates, and what impact can it have on fostering an inclusive classroom? Observation data showed a significant difference in engagement across all the groups that took part in the study except one group in the special education school. Despite this, teachers’ views across all test centres were very positive where impact on engagement was concerned. Furthermore, teachers highlighted the benefits they observed in individual learners that validated the quantitative data findings.

Observation data suggested that digital game making was as effective as traditional methods in fostering collaboration among peers and in two test centres significant increases were observed. Teachers also observed instances of collaboration in their classes, particularly in higher ability students helping those who had difficulty. This study did not examine instances of other student emotive outcomes (e.g., satisfaction or pride) but teachers appeared to note a clear impact on learner behaviour. Future studies should include these outcome measures in their evaluation strategies, as well as considering an

assessment of persistence in learning. The observation tool could be expanded to capture these, and future work should seek to advance such an instrument. This also highlights the importance of adopting a mixed methods approach in capturing the nuances of learning in real settings and the challenges this represents.

Increases in engagement would suggest a generally inclusive environment, as more students were able to engage with aspects of the lesson. Indeed, teacher responses suggest that students who typically struggled in sessions were able to engage in at least some aspects of the sessions due to the multi-modal nature of the pedagogical practice. The game templates allowed less able students to focus on content creation rather than complex programming concepts. Session learning outcomes were the focus of the content created and the tablet devices provided multiple avenues for the development of assets (camera, paint applications, etc.)

RQ2. What are the outcomes, benefits and challenges to using such approaches in classroom teaching? As noted in the RQ1 discussion above, teachers highlighted a variety of benefits from digital game making that they observed. These include increased motivation to learn, and an apparent persistence to learn particularly in those students who typically appeared at risk from social exclusion. However, there is a need to find a balance between the intended curriculum delivery and programming within sessions. Teachers highlighted a need for a larger bank of game templates and the accompanying material to utilise them within sessions such that only a small amount of session time is spent debugging code. The programming knowledge of teachers is still a concern and a potential barrier for wider scale adoption of digital game making in non-computer-based subjects.

This work has validated some of the benefits suggested by related work where digital game making is concerned and demonstrated through a comprehensive trial the improvement it can provide for learners across diverse classrooms in terms of providing an engaging and inclusive learning experience.

Future studies should focus on exploring the wider impact on learner characteristics. While this paper demonstrates evidence for impact on engagement and collaboration, teachers highlighted the need for more nuanced observations (of learning and behaviour) of their students in the sessions. For example, students appearing calmer or less disruptive during class. Future studies should expand observation protocols to gauge wider impact and perhaps consider elements of learning persistence; i.e., changes in general attitude toward learning outside of digital game making sessions.

In summary, this paper provides value through a comprehensive mixed-methods approach gathering data from a long-term pedagogical intervention across multiple, varied test centres providing evidence for the benefits of utilising VPL, facilitating digital game making in non-computing subjects. The use of game templates reduces barriers to adoption and maintains focus on curriculum learning outcomes rather than on learning to use the digital game making tools based on VPL. Further work is required to expand this utilisation of templates, continue to reduce barriers to wider implementation and adoption, and investigation of more nuanced learner behaviour change.

6 References

1. Akcaoglu, M., & Green, L. S. (2018). Teaching systems thinking through game design. *Educational Technology Research and Development*, 67(1), 1-19. <https://doi.org/10.1007/s11423-018-9596-8>
2. Alessi, G. J. (1980). Behavioral observation for the school psychologist: Responsive-discrepancy model. *School Psychology Review*, 9(1), 31-45. <https://doi.org/10.1080/02796015.1980.12086528>
3. Ary, D., & Suen, H. K. (1983). The use of momentary time sampling to assess both frequency and duration of behavior. *Journal of Behavioral Assessment*, 5(2), 143-150. <https://doi.org/10.1007/bf01321446>
4. Baytak, A., & Land, S. M. (2011). An investigation of the artifacts and process of constructing computers games about environmental science in a fifth grade classroom. *Educational Technology Research and Development*, 59(6), 765-782. <https://doi.org/10.1007/s11423-010-9184-z>
5. Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77-101. <https://doi.org/10.1191/1478088706qp063oa>
6. Breien, F.S. and Wasson, B., 2021. Narrative categorization in digital game-based learning: Engagement, motivation & learning. *British Journal of Educational Technology*, 52(1), pp.91-111. <https://doi.org/10.1111/bjet.13004>
7. Bulut, D., Samur, Y. and Cömert, Z., 2022. The effect of educational game design process on students' creativity. *Smart Learning Environments*, 9(1), pp.1-15. <https://doi.org/10.1186/s40561-022-00188>
8. Boulton, H., Brown, D., Hughes-Roberts, T., & Beltrán, M. E. (2020). Implementing Computer Game-Making Across the School Curriculum: Innovative Practice from Europe. *Innovating Education in Technology-Supported Environments* (pp.271–287).
9. Catrobat. (2017). Free educational apps for children and teenagers. [ONLINE] Available at: <https://www.catrobat.org/>. [Accessed 20 June 2019].
10. Denner, J. (2011). What predicts middle school girls' interest in computing? *International Journal of Gender, Science and Technology*, 3(1).
11. Denner, J., Campe, S., & Werner, L. (2019). Does computer game design and programming benefit children? A meta-synthesis of research. *ACM Transactions on Computing Education*, 19(3), 1-35. <https://doi.org/10.1145/3277565>
12. Dishon, G., & Kafai, Y. B. (2020). Making more of games: Cultivating perspective-taking through game design. *Computers & Education*, 148, 103810. <https://doi.org/10.1016/j.compedu.2020.103810>
13. Durak, H.Y. and Güyer, T., 2022. Design and development of an instructional program for teaching programming processes to gifted students using scratch. *In Research Anthology on Computational Thinking, Programming, and Robotics in the Classroom* (pp. 127-155). IGI Global. <https://doi.org/10.4018/978-1-6684-2411-7.ch007>
14. Eiselt, K., & Carter, P. (2018). Integrating social skills practice with computer programming for students on the autism spectrum. *2018 IEEE Frontiers in Education Conference (FIE)*. <https://doi.org/10.1109/fie.2018.8659252>
15. Fessakis, G., Gouli, E., & Mavroudi, E. (2013). Problem solving by 5–6 years old kindergarten children in a computer programming environment: A case study. *Computers & Education*, 63, 87-97. <https://doi.org/10.1016/j.compedu.2012.11.016>
16. Fisher, S., & Jenson, J. (2016). Producing alternative gender orders: A critical look at girls and gaming. *Learning, Media and Technology*, 42(1), 87-99. <https://doi.org/10.1080/17439884.2016.1132729>

17. Gabriel, S., & Vienna, K. P. H. (2018, October). We Make Games: An Evaluation of Introducing Game Design Concepts in Schools. In *ECGBL 2018 12th European Conference on Game-Based Learning* (p. 117). Academic Conferences and publishing limited.
18. Gaeta, E., Beltrán-Jaunsaras, M. E., Cea, G., Spieler, B., Burton, A., García-Betances, R. I., Cabrera, Umpiérrez, M. F., Brown, D., Boulton, H., & Arredondo Waldmeyer, M. T. (2019). Evaluation of the create@ school game-based learning–teaching approach. *Sensors*, 19(15), 3251
19. Glas, R., van Vught, J. and Werning, S., 2021. ‘Thinking Through’ Games in the Classroom: Using Discursive Game Design to Play and Engage with Historical Datasets. *Transactions of the Digital Games Research Association*, 5(3). <https://doi.org/10.26503/todigra.v5i3.126>
20. Griffiths, M. D. (2002). The educational benefits of videogames. *Education and health*, 20(3), 47-51.
21. Hollingshead, A., Carnahan, C., Lowrey, K. A., Snyder, K. (2017). Engagement for students with severe cognitive disabilities: The need for a common definition in education. *Inclusion*, 5, 1-15. [Doi:10.1352/2326-6988-5.1.1](https://doi.org/10.1352/2326-6988-5.1.1)
22. Hollingshead, A., Williamson, P., & Carnahan, C. (2018). Cognitive and emotional engagement for students with severe intellectual disability defined by the scholars with expertise in the Field. *Research and Practice for Persons with Severe Disabilities*, 43(4), 269-284. <https://doi.org/10.1177/1540796918812803>
23. Iovannone, R., Dunlap, G., Huber, H., & Kincaid, D. (2003). Effective educational practices for students with autism spectrum disorders. *Focus on Autism and Other Developmental Disabilities*, 18(3), 150-165. <https://doi.org/10.1177/10883576030180030301>
24. Hughes-Roberts, T., Brown, D., Boulton, H., Burton, A., Shopland, N., & Martinovs, D. (2020). Examining the potential impact of digital game making in curricula based teaching: Initial observations. *Computers & Education*, 158, 103988.
25. Hughes-Roberts, T., Brown, D., Standen, P., Desideri, L., Negrini, M., Rouame, A., Malavasi, M., Wager, G., & Hasson, C. (2019). Examining engagement and achievement in learners with individual needs through robotic based teaching sessions. *British journal of educational technology*, 50(5), 2736–2750.
26. Kafai, Y. B., & Burke, Q. (2015). Constructionist gaming: Understanding the benefits of making games for learning. *Educational Psychologist*, 50(4), 313-334. <https://doi.org/10.1080/00461520.2015.1124022>
27. Kafai, Y. B., Lee, E., Searle, K., Fields, D., Kaplan, E., & Lui, D. (2014). A crafts-oriented approach to computing in high school. *ACM Transactions on Computing Education*, 14(1), 1-20. <https://doi.org/10.1145/2576874>
28. Kalelioglu, F., & Gülbahar, Y. (2014). The Effects of Teaching Programming via Scratch on Problem Solving Skills: A Discussion from Learners’ Perspective. *Informatics in Education*, 13(1), 33-50.
29. Kalmpourtzis, G. (2018). Connecting game design with problem posing skills in early childhood. *British Journal of Educational Technology*, 50(2), 846-860. <https://doi.org/10.1111/bjet.12607>
30. Kangas, M. (2010). Creative and playful learning: Learning through game Co-creation and games in a playful learning environment. *Thinking Skills and Creativity*, 5(1), 1-15. <https://doi.org/10.1016/j.tsc.2009.11.001>
31. Ke, F. (2014). An implementation of design-based learning through creating educational computer games: A case study on mathematics learning during design and computing. *Computers & Education*, 73, 26-39. <https://doi.org/10.1016/j.compedu.2013.12.010>

32. Kelly, P. A., Haidet, P., Schneider, V., Searle, N., Seidel, C. L., & Richards, B. F. (2005). A comparison of in-class learner engagement across lecture, problem-based learning, and team learning using the STROBE classroom observation tool. *Teaching and Learning in Medicine*, 17(2), 112-118. https://doi.org/10.1207/s15328015t1m1702_4
33. Laakso, N. L., Korhonen, T. S., & Hakkarainen, K. P. (2021). Developing students' digital competences through collaborative game design. *Computers & Education*, 174, 104308. <https://doi.org/10.1016/j.compedu.2021.104308>
34. Lombardi, G., 2022. Acquiring Problem-Solving Skills Through Coding Games in Primary School. In *Handbook of Research on Acquiring 21st Century Literacy Skills Through Game-Based Learning* (pp. 697-715). IGI Global.
35. Lye, S. Y., & Koh, J. H. (2018). Case studies of elementary children's engagement in computational thinking through scratch programming. *Computational Thinking in the STEM Disciplines*, 227-251. https://doi.org/10.1007/978-3-319-93566-9_12
36. Malinverni, L., Mora-Guiard, J., Padillo, V., Valero, L., Hervás, A., & Pares, N. (2017). An inclusive design approach for developing video games for children with autism spectrum disorder. *Computers in Human Behavior*, 71, 535-549. <https://doi.org/10.1016/j.chb.2016.01.018>
37. Maloney, J. H., Peppler, K., Kafai, Y., Resnick, M., & Rusk, N. (2008). Programming by choice. *ACM SIGCSE Bulletin*, 40(1), 367-371. <https://doi.org/10.1145/1352322.1352260>
38. Meishar-Tal, H. and Kesler, A., 2021. "If I create a game I'll learn": online game creation as a tool to promote learning skills of students with learning difficulties. *Interactive Learning Environments*, pp.1-12.
39. Munoz, R., Villarroel, R., Barcelos, T. S., Riquelme, F., Quezada, A., & Bustos-Valenzuela, P. (2018). Developing computational thinking skills in adolescents with autism spectrum disorder through digital game programming. *IEEE Access*, 6, 63880-63889. <https://doi.org/10.1109/access.2018.2877417>
40. No One Left Behind. (2017). Unlocking student's full potential through video game development. [ONLINE] Available at <http://no1leftbehind.eu/>. [Accessed 19 June 2019].
41. O'Malley, K. J., Moran, B. J., Haidet, P., Seidel, C. L., Schneider, V., Morgan, R. O., Kelly, P. A., & Richards, B. (2003). Validation of an observation instrument for measuring student engagement in health professions settings. *Evaluation & the Health Professions*, 26(1), 86-103. <https://doi.org/10.1177/0163278702250093>
42. Rangvid, B. S. (2018). Student engagement in inclusive classrooms. *Education Economics*, 26(3), 266-284. <https://doi.org/10.1080/09645292.2018.1426733>
43. Rapp, J. T., Colby-Dirksen, A. M., Michalski, D. N., Carroll, R. A., & Lindenberg, A. M. (2008). Detecting changes in simulated events using partial-interval recording and momentary time sampling. *Behavioral Interventions*, 23(4), 237-269. <https://doi.org/10.1002/bin.269>
44. Resnick, M., Maloney, J., Monroy-Hernández, A., Rusk, N., Eastmond, E., Brennan, K., Millner, A., Rosenbaum, E., Silver, J., Silverman, B., & Kafai, Y. (2009). Scratch. *Communications of the ACM*, 52(11), 60-67. <https://doi.org/10.1145/1592761.1592779>
45. Silander, P., Riikonen, S., Seitamaa-Hakkarainen, P., & Hakkarainen, K. (2020). Learning computational thinking in phenomenon-based co-creation projects—Perspectives from Finland. In *In SC Kong & H. Abelson (Eds.), Computational Thinking Education in K-12: Artificial Intelligence Literacy and Physical Computing*. MIT Press.
46. Slany, W. (2014). Pocket code. Proceedings of the companion publication of the 2014 ACM SIGPLAN conference on Systems, Programming, and Applications: Software for Humanity – SPLASH '14. <https://doi.org/10.1145/2660252.2664662>

47. Spieler, B., Schindler, C., Slany, W., Mashkina, O., Beltrán, M. E., Boulton, H., & Brown, D. (2018). Evaluation of game templates to support programming activities in schools. <https://arxiv.org/abs/1805.04517>
48. Standen, P. and Brown, D., 2014. Mobile learning and games in special education. *The Sage Handbook of Special Education: Second Edition Second*, 2, pp.719-730.
49. Thumlert, K., de Castell, S., & Jenson, J. (2018, October). Learning through game design: A production pedagogy. In *Proceedings of the 12th European Conference on Game-Based Learning ECGBL*.
50. Uğraş, T., Rızvanoğlu, K. and Gülseçen, S., 2022. New co-design techniques for digital game narrative design with children. *International Journal of Child-Computer Interaction*, 31, p.100441. <https://doi.org/10.1016/j.ijcci.2021.100441>
51. Werner, L., Denner, J., & Campe, S. (2014). Using computer game programming to teach computational thinking skills. *Learning, education and games*, 1, 37-53.
52. Zubair, M.S., Brown, D., Hughes-Roberts, T. and Bates, M., 2018. Evaluating the accessibility of scratch for children with cognitive impairments. In *Universal Access in Human-Computer Interaction. Methods, Technologies, and Users: 12th International Conference, UAHCI 2018, Held as Part of HCI International 2018, Las Vegas, NV, USA, July 15-20, 2018, Proceedings, Part I 12* (pp. 660-676). Springer International Publishing.

7 Appendices

7.1 Appendix A

Teacher Interviews

Following completion of a significant amount of intervention sessions, the following interview protocol was implemented to explore teacher perceptions and progress within the project.

Overview of Teacher Interview Questions

Semi-structured – interesting points should be explored further but without too much deviation from the script.

- Can you summarise how Create@School is currently/has been used in your classroom?
- How would you assess the impact it has had on the student’s learning experience?
- Have you noticed any changes in the way the students learn within sessions driven by Create@School?
- Have you noticed any changes in student attitudes within sessions driven by Create@School?
- Have you observed any changes from the previous two points within other sessions since taking part in Create@School sessions?
- Can you give any examples of particular students that have particularly reacted to Create@School sessions?

Interviewer note: positively or negatively if requiring some prompts but avoid leading questions.

- Would you feel confident employing Create@School driven sessions in the future, without the support of the NOLB project team?
- If so, where do you see yourself using Create@School in the future?
- Can you give an overview of how you might introduce it?

Interviewer note: subject area, general outline of sessions – why was this example chosen could be an interesting area to explore if possible.

- If not (from question 6), what support do you think you would require to become comfortable working with Create@School independently?
- Is there anything else that would make the introduction of Create@School long term difficult?