Transitioning to a Digital Educational Environment

A Lecturer's Perspective on Migrating to Google Classroom During the COVID-19 Pandemic in Trinidad and Tobago

JASON ROBERT RAMESHWAR

Abstract

This paper highlights disruptions to traditional learning environments in the Trinidad and Tobago educational system during the COVID-19 pandemic. It outlines issues due to social distancing restrictions as well as strategies using digital integrations to achieve educational continuity.

This research focused on a case study of a lecturer's experience in educational digital transformation using Google Classroom. It was done through direct observations of each student's response to changes in the educational platform and style of learning. This involved administration of ad hoc open-ended unstructured qualitative questions to students during the transition. The students' feedback identified thematic areas (of digital well-being, digital transformation, and online platform access) that were used in a scoping literature review using Google Scholar.

The effect of transitioning from the physical classroom to an online platform revealed that the majority of students were able to access the system with limited disruption.

Practical implications of this experiential case study would be the application of the developmental elements of the digital transformation policy. This involved the identification of a best practice approach. This achieved *four pillars of Industry 4.0 benefits, and also identified the use of interactive elements as extended reality (AR, VR, MR) and haptic technologies for STEAM focused courses.*

The value of the paper is in the detailed use of the Google platform and provision of a solution for easier integration of remote applications to enable a faster migration to alternate teaching modalities.

Keywords: digital integration; asynchronous assessment; disruptive education

Contextual Background

The author has been a lecturer at a Trinidadian tertiary institution for approximately ten years in which the primary mode of disseminating information and immediate evaluation was via face-to-face, with class sizes ranging from five to over twenty students. The composition of students within a particular class varied in terms of age (limits of 18 to 60+ yrs), gender, family structure (single, married, parents), ethnicity, educational background (secondary and tertiary schools), and technical experience (industrial and non-industrial).

Classes were abruptly ended on the 14 March 2020 due to the seriousness of the COVID-19 pandemic. The need for continuity was critical to ensure students received contractual teaching days. Google Classroom was identified as the digital learning environment to continue classes.

For confidentiality, the following details are withheld from this paper:

- Name and location of the educational institution
- Course(s) that transitioned to the online mode
- Names of lecturer(s) and student(s)

Limitations

The research is based only upon the author's experience and the feedback of the students involved in the taught classes during the COVID-19 pandemic period. It does not investigate the effects of the transition on other functions of the institution. The focus is only on the Google Classroom platform provided by the author's educational institution and not on other types of online collaborative or learning management systems (LMS). The research does not aim to provide a justification for the selection of a specific type of learning environment.

Literature Review

Google Classroom is identified as an effective digital learning environment (Kumar, Bervell, and Osman 2020; Al-Maroof and Salloum 2020; Albashtawi and Al Bataineh 2020; Abd. Syakur, Sugirin, and Widiarni 2020; Joy et al. 2018) most institutions, including Malaysian higher educational institutions, are adopting this learning management system (LMS, although it has a drawback in that "students lack understanding of lecture material" (Fitri Rahmawati, Zidni, and Suhupawati 2020). Thus, although it is a useful short-term alternative to in-class sessions, Google Classroom is not a direct replacement.

This adoption increased as a result of the lockdown restrictions of COVID-19, in which digital alternatives were identified to provide remote access to educational resources ("Teachers/Students Being Provided with Access to Google Classroom", Loop News 2020a; *Barbados Today* 2020; De Vynck and Bergen 2020). Caribbean educational institutions transitioned to the use of Google Classroom either directly or with the aid of third-party ICT companies, such as Blue Chip Technologies. This company enabled Google Classroom environments for "Naparima College, St Peter's Private Primary School, Cedar Grove Primary School and San Fernando TML School" (De Silva 2020) and noted the key benefits, as the system is always-on and available 24/7, and also facilitates remote interactions between teachers and students. However, the benefits were limited by the ability to access ICT equipment and the internet. Thus, there was a minimum set of resources required to effectively utilise the online system. Teachers and students without key equipment were at a disadvantage as classes resumed online.

The change from a structured educational environment (with defined parameters as dress code, assigned seating, permission for taking breaks) to a flexible and unstructured home-based environment (reduced enforcement of rules and regulations) created freedom of choice for teachers, students, and parents (or guardians). Reports have been made regarding inappropriate attire whilst visible via the webcam, interruptions during the lessons, direct assistance to answering assessments and use of unauthorised devices ("10 Ways Parents Disrupt Children's Google Classrooms during COVID-19" 2020b). This home-based system increased the exposure to noise hazards, as parents continually experienced the sounds of interactions in an online class (Gooding 2020). This introduced the issues of privacy and digital well-being as critical factors.

Google Classroom appeared in 2014 (Etherington 2014; Kahn 2014) and evolved to integrate various applications to enhance the functionality of the learning environment. It facilitated the interconnection between physically separate educational resources (teachers and reference material) in a flexible digital environment in which students can access these facilities from any physical location (once there is a connection to the internet). This change in the learning environment is part of the Industry 4.0 (I4.0) concept applied to education. The I4.0 concept can be defined as "the evolutionary change in decentralised connected systems to enable the intelligent integration of the horizontal and vertical value chains of an organisation" (King, Rameshwar, and Syan 2020, 370). Many of the benefits of I4.0 can be realised by this educational evolution, as

- real-time communication between teacher and student;
- individual attention as well as customised lesson plans and learning outcomes;
- access to multiple sources of information to develop strategic, innovative, sustainable, and critical thinking that develop intelligence;
- economical use of assets via the Cloud platform.

The transition from physical to virtual is problematic (Vincent 2020a; 2020b) as the learning paradigm becomes individualised (a by-product of I4.0). Copyright infringement due to reference material being shared with students online attracts severe penalties (Paul 2020). Unauthorised access has encouraged class disruptions once the class access code and password were provided (News Desk 2020). Users of the platform and content creators must understand the effects of the digital learning environment on pedagogical factors as "ease of access, collaboration, student voice/agency and pace" (Heggart and Yoo 2018) and recognise the transition is not seamless. This reinforces the point that educators must be part of the change process to modify their existing strategies to incorporate new technologies into each student's development as it is "not enough to put technology into the classroom" (Helleve and Almås 2017).

Methodology

The rationale for the research was the result of experiences of the digital transition from the physical classroom to the Google Classroom system. This transformation involved the author and fifteen students. As such, the research was reflexive, ethnographic, and anecdotal (Fleming and Fullagar 2007; Dupuis 1999; Gergen and Gergen 1991; den Outer, Handley, and Price 2013; Koballa 1986). These processes identified the initial (unfiltered and unbiased) impressions of the immediate users of the new platform. The feedback was not influenced by the boundaries of a structured or closed-ended questionnaire and neither via the presence of an interviewer, as the only interactions were those between a teacher and the students.

This was not an unbiased study as the researcher was one of the subjects. However, there was validity in capturing the responses and performing an analysis to identify key thematic areas that affected the change.

The specific modalities implemented were the case study and ad hoc open-ended unstructured qualitative questions. The former involved the direct observation of each student's response to changes in the educational platform and style of learning. The latter was based on the experiential feedback of both the students and the author. Each qualitative question was developed in direct response to a student's comments to the prescriptive and forced modifications of the learning environment.

Anecdotal evidence was derived through an examination of personal opinions on the change in teaching modality from face-to-face to online. This provided an initial research framework without any pre-existing data on the forced movement to online education (i.e. there was no direct need to utilise Google Classroom to ensure class continuity due to a disruption).

These covered thematic areas of

- **Digital well-being factors**, such as
  - o ability to sit, view a screen, type and talk continuously for 3 hours
  - o eye strain
  - o leg cramps
  - o posture due to a poorly designed ergonomic chair, desk, keyboard, monitor or foot rest
  - o effect of adding 3 hours of continuous computer usage to an existing daily computer use;

- **Access to Google Classroom and Google Meet** which were dependent upon
  - o reliable internet and electricity on the scheduled class dates and for the duration of each session
  - o ability to access the Classroom and its resources, including the Google Meet live sessions

    - functional microphone and speaker for real-time bi-directional audio communication;

- **Transitioning to online** which was affected by
    - distractions due to noisy locations, where users participated in Google Meet, as well as the use of other electronic devices (hidden from view)
    - disconnected feelings of users due to the lack of physical presence
    - reduced preparedness for sessions due to a loss of structured "school" atmosphere, as the routine "for school" was changed
    - increased anxiety due to uncertainty about procedures for assessments (mid-term, group project and final exams).

A scoping literature review (Munn et al. 2018; Arksey and O'Malley 2005) using Google Scholar (Haddaway et al. 2015; Cole et al. 2018) of thematic areas was performed. A comparative analysis was made between the observed responses (and anecdotal data) and the data from the literature reviews to develop a strategy and solution for integrating digital services for education.

Results and Analysis

Transition to Google Classroom

The transition flowchart (figure 1) was based upon the process to move the physical in-class sessions to the Google Classroom platform. Analysis of this process highlighted that a successful transition to a digital classroom environment is based upon key segments, as

- allotted time for teacher training;
- digitalisation of learning resource material;
- customisation of system parameters to satisfy each student's individual requirements.

Thus, the creation of a digital classroom is dependent upon the consideration of the following activities:

- digital twinning of the physical environment;
- duplication of the course structure;
- maintenance of the class process.

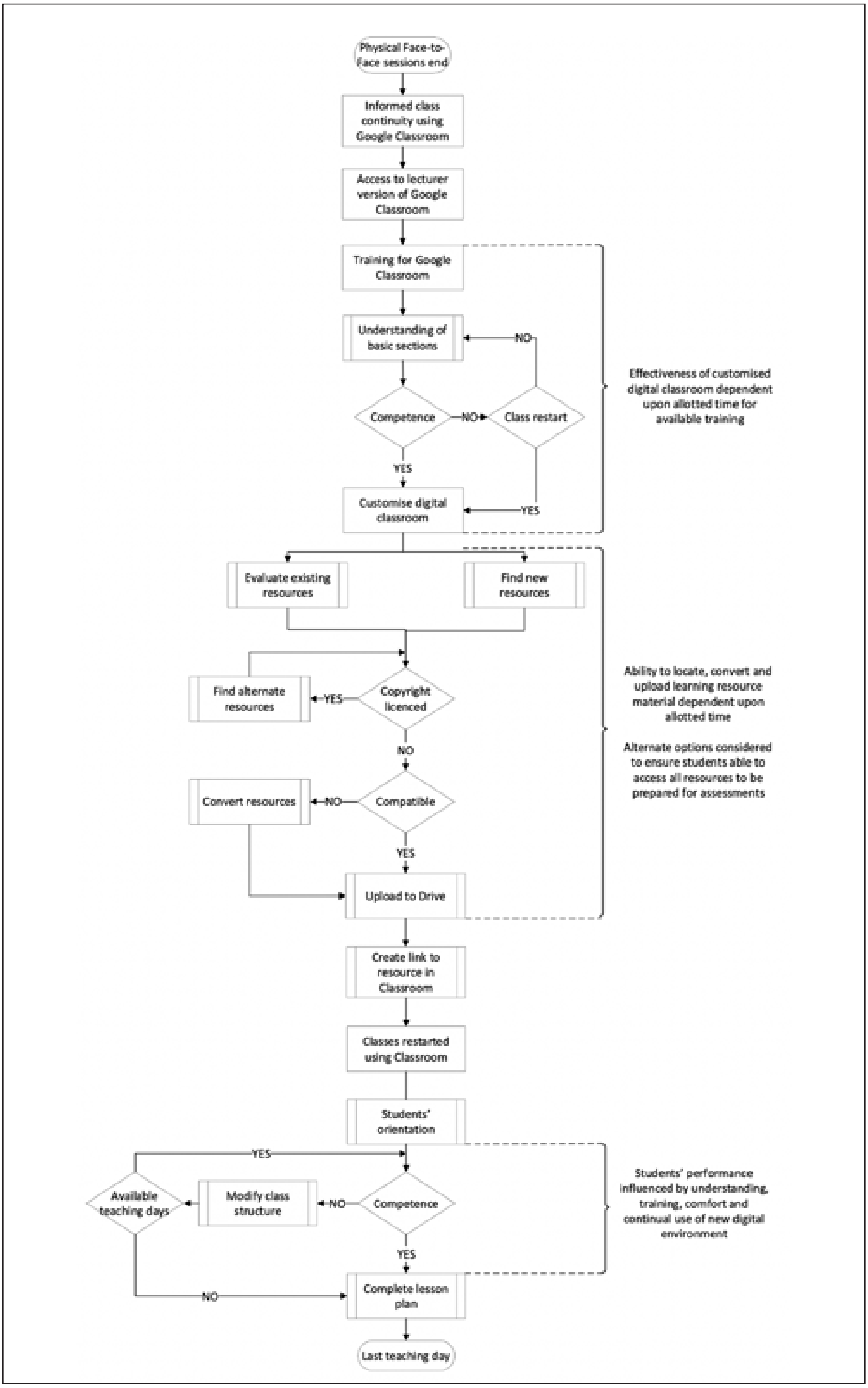

Figure 1. Process flow chart of the transition to digital classroom

Digital Twinning of the Physical Environment

This involves the duplication of the physical assets into the digital world to enable persons to "monitor, understand, and optimize the functions of all physical entities" (El Saddik 2018, 87). This process minimises disruption due to the change in the environment as each physical system contains with their operation, the exact digital twin with which persons will be familiar. A digital class should incorporate the following elements as they were used in the execution of the task:

- writing surface (white/blackboard) and writing materials (coloured markers and eraser) accessible to all participants;
- ability to see and hear each person (teacher and students);
- projector and screen to illustrate information simultaneously to a group;
- ICT equipment as computers, whose primary function is to transfer information to the projector;
- library reference materials that have been identified as course resource information as well as being essential for students' research.

Duplication of the Course Structure

This enables the original class structure to be maintained within the digital environment. It allows seamless continuity during the transition, as both teachers and students are accustomed to the pre-existing structure, modes of operation, and requirements of each activity, such as

- continuation of lesson plan;
- group project work (assessments, presentations and breakout activities);
- individual activities (assessments, in-class assistance and in-class activities);
- after-class assistance (office hours, communication via email or phone).

Maintenance of Class Process

The new digital environment enabled access to the class sessions from remote environments (as individual's homes, work, and vehicles via personal ICT equipment such as desktops, laptops, tablets and phones). However, it did not change the nature of the activity and as such should maintain the format in which the physical class was conducted, as

- scheduled start and end times;

- allowances for breaks (including bathroom);
- attendance records;
- minimising (or eliminating) internal and external distractions.

The ability to duplicate the functionality of each item determined the effectiveness of the transition to a different learning environment with minimal disruption or reduced time to restart the teaching process. However, this process is dependent upon the digital platform and available integrated applications. Creating the exact functional environment would achieve the benefit of minimal delays to continuation as well as adherence to a pre-established pattern of class activity that influenced student behaviour.

Digitalisation mapping

A review of mapping elements of a physical classroom onto the digital environment identified that many of the physical classroom requirements have a suitable digital equivalent through software systems. However, ICT equipment, class breaks, and minimising distractions do not have a direct digital twin.

ICT systems require hardware to physically connect to an existing network and access the internet. This is provided through a wired or wireless connection to an Internet Service Provider (ISP) that is typically enabled through a computer (fixed or mobile device). The minimum requirements are

- ISP connection through a wired or wireless medium;
- modem that converts the ISP signal;
- wired and/or wireless router (that is either built into the modem or as a separate unit);
- computer device (desktop, laptop, tablet, phone) that contains a network card to translate internet network protocols for use by web-based applications;
- input and output communication devices to enable bi-directional communication as
    - o camera (for video and photos)
    - o screen (visual display unit)
    - o microphone and speakers (for audio)
    - o keyboard, mouse, pen, touchscreen (for selecting options, writing text, drawing).

Due to the remote nature of digital classrooms, there is no continuous oversight and direct management by a teacher. Therefore, breaks and distractions are influenced and controlled by the end-user (i.e. the student and their immediate surroundings). Teachers are only able to monitor the content provided by the student's input devices as well as applications that share (e.g. screen share).

Therefore, a digital learning environment must be evaluated and designed based upon these limitations in order to maintain the same functionality as a physical classroom. However, there are critical classroom activities that involve interactions between the teacher and students, as

- teacher-class, in which the emphasis is on the teacher speaking about the topic to the entire class as a group;
- student-student, involving direct discussion between two students in situations as clarification and assistance of assignments or lessons;
- teacher-student interactions, satisfying the direct assistance activities that provide personalised evaluation of a student's assignment, clarification of lesson(s) and providing advice on a range of topics initiated by the student;
- display information activity, encompassing any visual presentation of information (including explanations) to the students from reference materials to course assignments;
- assessment incorporating various forms of examining the student's progress in the course;
- presentation specific to the group presentations that may be part of the assessment activity.

An analysis of the minimum resources needed to satisfy the implementation of these activities identified ICT equipment and connection to the internet as critical systems for a digital classroom. To achieve the main activities as teacher-class and teacher-student, additional systems required were meeting software, microphone, speaker and access to email. Thus, both teachers and students would be able to exchange documents through email as well as engage in live audio lectures and discussions via the meeting software, microphone, and speakers.

Negative effects of digital classrooms

Although beneficial in enabling the continuity of activities, the use of digital technologies has the ability to create disastrous effects. The digital realm creates privacy issues regarding unauthorised recording of video and/or photos and/or audio during a live class session. Confidential information captured could be accidentally or deliberately exploited by the user and/or third parties that acquired access. For example, the subject's image and/or signature may be copied and used in negative contexts. The systems that enable this function are the web camera, microphone, screen share, and remote desktop.

Increased stress can occur due to the high frequency of messages received via email and phone (including phone calls, text messaging, and chat applications) as students are able to engage in 24/7 communication with teachers (as compared to the limited time interaction of physical classes and school environment). There is an expectation that responses should be immediate since no protocol has been developed to guide the behaviour regarding the platform.

In addition to the psychological stressors (as noted above), individuals experience physiological changes due to the length of time spent operating input devices. Prolonged stationary positions affect the musculo-skeletal system. Repetitive movement can lead to repetitive strain injuries in the wrist and fingers. Effects on the eyes such as "eyestrain, visual discomfort, and visual fatigue" (Matula 1981, 581) are linked to continuous use of visual display units (screens of computers, tablets, phones, and televisions).

Integration of apps

Integrating minimum required apps (attendance registers, countdown clocks, digital well-being tools, and privacy tools) automatically into the Google Classroom platform would provide the additional features for an effective digital transition. The automatic provisioning of applications can solve attendance discrepancies; issue reminders to take breaks and change tasks; reduce the negative physical and emotional effects of consistent usage of digital devices; easily incorporate drawings; visually demonstrate concepts on built-in whiteboards; as well as maintain privacy. The last feature is required to prevent unauthorised access to each person's system as well as to prevent the unauthorised ability to share or alter information (video, images, audio) of participants.

System flaws

A review of integrated features is summarised in the following paragraphs. This identified systemic operational design flaws that limit their effective use.

The ability to disconnect all participants at the end of a session was not provided as a visible option that could be enabled (or disabled). The only way to test the presence of the feature was to deliberately end a session prematurely and then try to reconnect to observe the students' status. Thus, this was not tested and its automatic integration could not be verified.

The originality report only worked when the assignment was uploaded using Google Docs. It did not check attachments submitted.

Specific features, as the camera blur (Pradhan 2020), were only operational using the Google Chrome browser. There is freedom of choice in the selection of alternate browsers, based upon personal preferences that included security (Kelly 2020), that affect the access to certain features.

The Jamboard whiteboard feature was not activated as part of the institution's package although it was accessible via a personal Google account as a separate application as well as an embedded link in the Meet application. However, this change appeared in April 2021 as part of the built-in options. This feature update (as well as others) was identified as planned additions to the Google Meet and Classroom ecosystem (Yeskel 2020).

Although video recordings were integrated, their initial functionality was poor due to the record button's unavailability during some sessions. In addition, the videos were not automatically uploaded to students' Google Drive accounts for immediate access. The latter was solved through the use of a video request form that was emailed only to students who requested access to the videos. However, sessions that were not recorded had no data for students to access.

Online education is dependent upon web-based applications. Failures in these systems affect access to learning material and resources. A review of the available information on the G Suite Status Dashboard (Google n.d.) from 19 August to 17 October revealed that Classroom experienced no interruptions, whereas Meet experienced outages in August and September (20 August – 2 a.m. to 6 a.m.; 24 September – 9:30 p.m. to 10 p.m.).

G Suite applications

Google provided access to a range of their developed applications as Classroom, Meet, Jamboard and Drawings. This provided an inherent level of trust in the functionality, security, and compatibility with various G Suite programs. They also provided access to a growing suite of third party programs (Google n.d.). The fundamental difference between the two is security.

There are many applications that can be integrated to work with Google Classroom through the configuration of an API (application programming interface) (Google n.d.; Google Developers n.d.) that is used to create a functional educational platform, as in an automatic attendance tracker (Google Developers 2020). However, the easiest approach is the ability to enable pre-selected Google applications.

Google Classroom platform

This section provided a practical overview of the Google Classroom environment from the first interaction to a class structure.

A valid Gmail address or an educational institution email, which is linked to the Google Classroom, is required to gain access to the platform in order to join or create a class. Thus, access to the platform without an educational email address required confirmation that the classroom created will not be used at a school or university with students. This warning highlighted that the availability of integrated services was dependent upon the institution and their G Suite for Education account. This warning only appeared when accessing the system with a personal Gmail account.

The main page of the newly formed classroom contained the basic class information (class name, class name – Section, Class code as well as the Google Meet link, if provided by the IT Administration) and a summary of activities or direct messages via the "Stream" tab. The benefit is in providing easy access to the course and being aware of the most recent changes to the content.

The "People" tab provided a list of teachers and invited students (and their status of joining the class). Emails can be directly sent via this portal to either individuals or a group. The "Marks" (or "Grades" for the institutional account) tab summarised all the assignments issued to the class and included the due date, class average, submitted (on-time or late) and outstanding, as well as any marks allocated. A student or assignment can be selected to focus on a specific aspect. The "Classwork" page is either blank (for personal accounts) or pre-populated (by either the school's IT Administration and/or Distance Learning Co-ordinator). However, in each case the same options for "Create" were available. These functions enabled customisation of the classroom environment (as referenced in figure 1). The basic layout options were Assignment, Quiz assignment, Question, and Material. Flexibility to create a new resource (document, presentation, spreadsheet, diagram or form) is provided using the built-in Google Docs applications or via a link to a pre-existing source. The number of resources as well as types of options is limited by the storage size of the Google Account.

The ability to organise the "Classwork" page by activity, date or information type enhanced the customisation of the classroom experience. These "Topics" provided a structured approach to teaching and learning, as related material can be grouped into a specific section as well as hidden from the students and only made visible based upon the teacher's preference.

The initial desire is to duplicate the exact structure of the physical class, in terms of the weekly lessons and their associated materials and activities.

Google Meet is the meeting software application that enables the direct interaction between the teacher and the class. A direct meet link may be provided by the institution, however it can also be created through the Calendar application by creating a link as a resource using any of the previous methods or directly in the Calendar via the "Join with Google Meet" button.

Google Meet may be embedded with specific features dependent upon the type of account. At a minimum it enabled bi-directional interaction (i.e. both teacher and students can communicate simultaneously) via audio (with the use of ICT equipment), via video (if enabled as there may be privacy concerns), via text messaging (through the chat feature), as well as via an integrated Jamboard (Google's version of a virtual whiteboard). The option for recording the meeting enabled viewing on demand. Additional host controls allowed the teacher to control the students' microphones and ability to share their screens as well as chat. However, these must be enabled by the institution.

Suggested Best Practice

Digital transformation from a physical classroom, using Google Classroom as the LMS, should involve an iterative process (as illustrated in figure 1), in which both teachers and students clearly identify the key objectives for both the learning requirements (of the specific course) and the modes of teaching and learning. The following summarised the minimum suggestions for best practices, based on lessons learnt during the case study.

In order to mitigate problems of development, implementation, and effective use of the final solution, it is important that all key stakeholders (teachers, students, and ICT support personnel) are involved in each phase to provide input and guide the process.

The following thematic areas of focus are applied to each phase:

- digital well-being;
- access to online platform;
- transitioning form physical to digital (online).

Phase 1: Identify the type of digital classroom to be developed, taking into consideration

- digital twinning of the physical environment;
- duplication of the course structure;
- maintenance of class process.

Phase 2: Evaluate the need for each of the digital education transition factors below.

- Google Classroom access
- reliable Internet connectivity
- video conferencing hardware
- group project assessment
- automatic access to class videos
- final exam assessment
- plagiarism alert for final exam
- prior training for platform
- accessing copyrighted material
- Google Meet attendance records
- using one platform
- mid-term assessment
- practice assignments with feedback
- digital well-being
- privacy
- live class sessions

Phase 3: Iterate customisation of available digital classroom elements, including

- matching learning objectives, learning styles and teaching requirements
- creating a functional environment via the minimum digital resources for key activities of teacher-class interactions
    - o ICT
    - o internet
    - o meeting software

- microphone
- speaker
- email

- developing a functional environment via the required integration of apps
    - attendance
    - countdown clock
    - digital well-being
    - drawing
    - whiteboard
    - privacy

- Evaluate the effectiveness of customised solution(s) (as illustrated in table 1)

Table 1. Summary of iterative functions from the transition to digital classroom process

Teachers	Students
Competence in creating Classroom elements	Competence in using Classroom platform
Develop (or identify) suitable learning resource materials for online use	Measured KPIs of understanding, training, comfort and continual use of online platform

Suitability for STEAM Courses

The importance of evaluating the applicability to STEAM (Science, Technology, Engineering, Arts and Mathematics) is due to its being a "new transdisciplinary and interdisciplinary field that emerges in pedagogics" (Liritzis 2018, 73). The author highlights the benefits using STEAM in education as a "holistic approach in classroom" and "removes limitations and replaces them with wonder, critique, inquiry, and innovation" (73).

As identified in the previous section, the customised platform is developed through an iterative consultative process with teachers, students, and ICT support personnel. One of these key steps is the determination of the type of classroom to be created, including whether the course structure is to be duplicated.

Table 2 compares the basic teaching and learning requirements of STEAM courses with the traditional method (physical classroom environments using minimal resources as a whiteboard, projector, textbooks, and desktop computers) and the Google Classroom suggested best practice elements.

Table 2. Google Classroom suitability assessment of STEAM teaching and learning requirements

Teaching and Learning Requirements	Traditional Method	Google Classroom
Visualisation of text, videos and graphics that outline and explain key concepts of subject material	✓	✓
Creation of artistic expressions by manipulating physical objects (e.g. sculpture, modelling, dance, music, performance, crafts)	✓	✗
Development of complex technical and artistic drawings using various media (e.g. including 3D)	✓	✗
Writing complex mathematical, scientific and engineering equations	✓	✓
Teacher's demonstration of experiments	✓	✗
Student's physical manipulation of tools in supervised experiments	✓	✗

As illustrated above, Google Classroom is limited in adequately providing an interactive virtual medium for courses in STEAM. However, there is a strong focus to use XR (extended reality) mechanisms as VR (virtual reality), AR (augmented reality) and MR (mixed reality) in the educational environment (Yang, Zhou, and Radu 2020) as well as to include haptic feedback technologies that connect the virtual to the physical (Hamza-Lup and Adams 2008; Kreimeier et al. 2019). Although there is no current integrated XR application for Google Classroom, Google has provided access to virtualised educational environments as their Arts and Culture application (Google n.d.) and the ability to create virtual environments with tools as Tilt Brush (Google n.d.; Ho, Sun, and Tsai 2019), Tour Creator (Google n.d.) and Blocks (Google n.d.). As these options are part of the Google ecosystem, their integration into Google Classroom may be in the future. The immediate alternative is to use the screen share function in the meeting software to engage with the students.

Conclusion

The digital environment enabled continuity of essential educational functions that are performed in a physical classroom as teacher-class and student-student interactions with the use of ICT equipment, an internet connection and suitable applications (Google's Classroom and Meet).

The continuous feedback from the fifteen students, as they each experienced the forced rapid movement from physical classes to virtual classes, provided essential information about the "expectations and habits of Caribbean users of digital technologies" (Rameshwar 2020, 29). This number of students was not enough for a quantitative evaluation and this methodology was outside the scope of the paper.

However, their transition from a purely physical environment highlighted that it is not an easy nor straightforward process. This required an understanding of the limitations of the available digital resources as well as a strategy to modify the existing pedagogical structure, which included sufficient time for both educators and learners to accept, adjust, and adapt in an iterative cycle that created a customised learning environment to achieve the overall objectives of the lesson plan.

Google Classroom is a popular learning management system (LMS) that provided basic functionality in their free and corporate accounts. Educational institutions have the flexibility to add specific features that enhance the learning portal to make specific features easily available for both users (teachers and students). However, this is limited by the IT administrators' understanding and determining the tools needed for effective and efficient online interactions. Thus, as part of the change to digital, both teachers and students need to be included within the process as the system is configured to satisfy specific demands of individualised classes.

This changed the education paradigm as it moves closer to the concept of "education for one", in which each student's needs can be directly addressed using technology.

The concerns regarding privacy and digital well-being should not be overlooked as their effects will become increasingly pervasive due to the continual use of technology. The development of the curriculum must take this into account and create a shift from simply providing an online presence through which information can be exchanged.

Although blended learning environments existed for years and had been implemented in various institutions, the physical restrictions of COVID-19 created a necessity to move quickly and fully into the digital space and thus highlighted key problems within the transition.

Future transitions would benefit from a comprehensive policy that guides this activity. These developmental elements of a digital transformation policy structure are illustrated in figure 2, and are based upon the lessons learnt during

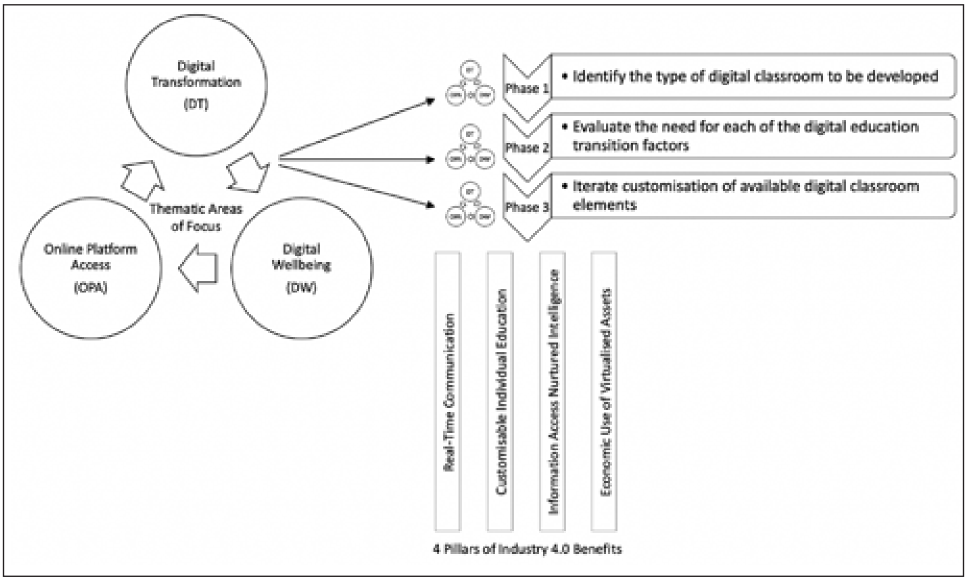

Figure 2. Developmental elements of a digital transformation policy structure

the transformation. This should create an educational revolution that achieves many of the benefits of Industry 4.0 as real-time communication between teacher and student; individual attention as well as customised lesson plans and learning outcomes; access to multiple sources of information to develop strategic, innovative, sustainable and critical thinking that develop intelligence; and economical use of assets via the Cloud platform.

These benefits would be facilitated by a three-phased process. Each stage would adopt the thematic areas of digital well-being; access to online platform; and digitalisation mapping of the physical world's resources to find equivalent/suitable applications in the digital world.

However, STEAM courses learning objectives require interactivity between the digital and physical realms (figure 3). This can be realised using a combination of XR and haptic technologies. This process enables forces, vibrations and motion to translate the digital information from virtual, augmented and mixed reality systems to the user.

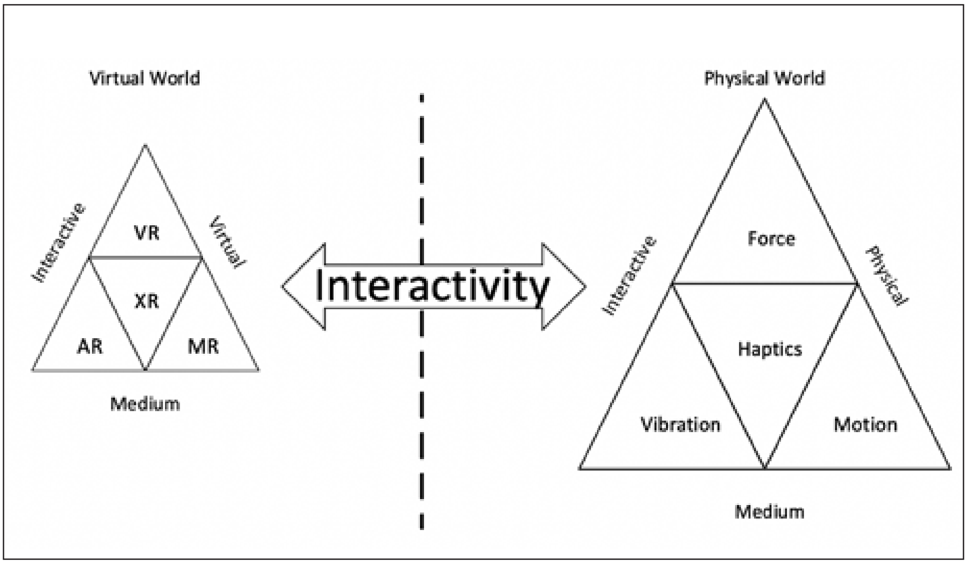

Figure 3. XR + Haptics provide interactivity

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