TECHNOLOGY CONSULTING
IN THE GLOBAL COMMUNITY

Final Consulting Report

Palau Ministry of Education

Vrinda Gupta & Caitlyn Low

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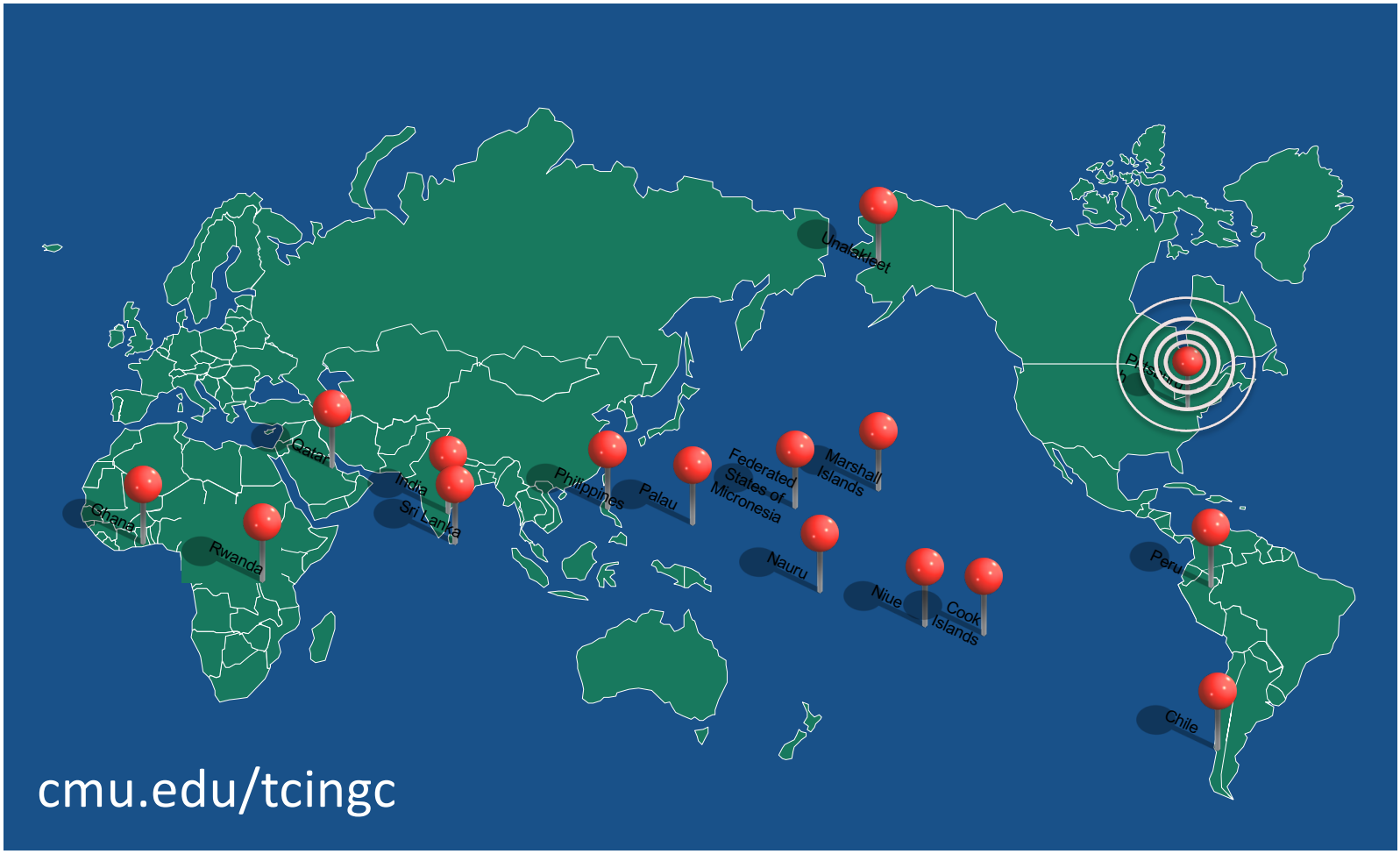
Carnegie Mellon University



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Ministry of Education
Executive Summary

Student Consultants, Vrinda Gupta and Caitlyn Low
Community Partner, Edwel Ongrung

I. About the Organization

The Palau Ministry of Education (MOE) is responsible for managing, operating, and promoting the public elementary and secondary school system and implementing the national educational curricula. Its mission is as follows:

> *The mission of the Republic of Palau's Ministry of Education, in partnership with parents and community, is to ensure that our children and youth preserve Palauan culture and become contributing citizens and productive workers in a changing world.*

The vision is similarly straightforward:

> *Our students will be successful in the Palauan society and the world.*

The Ministry is responsible for all matters pertaining to public education in the Republic.

II. Reconstructing EMIS, an SIS that is efficient and accurate

Elementary schools that are part of the MOE use an SIS that is part of an EMIS to track information on student biodata, enrollments, and grades. While this system serves the basic needs of the MOE, it falls short from meeting some of the MOE's more complex and critical needs. Some of these unmet needs include transcript generation, batch processing of student grades, and high data integrity.

Outputs of the project include:

- A normalized entity relationship diagram (ERD) of SIS
- A replacement full function class based SIS app for the MOE that allows:
    - Management of classes, enrollments/registrations, students, and academic years
    - Report card generation
    - Batch processing of student grades based on workbooks mandated by the MOE
    - Data validation
    - Authorization and Authentication
- Migration and cleaning of data from the existing SIS into the new application.
- Training for the staff in Meyuns Elementary School and the MOE on EMIS

Outcomes of the project include:

- Improved data integrity and accuracy that will persist through data validation
- Increased efficiency in searching for student information and report card generation, from hours to less than a minute
- A normalized database that will be the start of several reporting data pipelines

Risks of the project include:

- Lack of support for Ruby on Rails

- The cost of switching all other schools to the system in the upcoming years

Recommendations include linking the schools and employees tables directly to the database from which the data was pulled, adding a flag to incoming data in the old database, and implementing new modules.

III. Improving the MOE's reporting capabilities, specifically the speed of generating reports

The MOE takes weeks to generate, both annual and ~~not annual~~ ad hoc, reports. The goal was to decrease the amount of time it takes to do so.

Outcomes of the project include:

- Introduction of Data Analysis Stack (DAS), ETL and Business Intelligence concepts to the DRE
- Time it takes to generate a report down from weeks to days, if recommendations are implemented regarding the DAS

Outputs of the project include:

- A WordPress website
- A research paper on Business Intelligence tools and Data Analysis Stacks
- Presentation to DRE - video, presentation slides, presentation transcript
- Demonstrated the capability for Superset to create tables and charts for the Statistics Yearbooks using data available from the MOE (primarily from the SIS pipeline)
- Dashboard of graph examples for the Meyuns School
- Business Intelligence Tool - Apache Superset installed on MOE server and connected to the MOE database as well as Vrinda's SIS

Risks to Sustainability:

- Lack of support for Apache Superset
- Apache Superset is less effective overall, if the MOE does not move to implement a DAS

Recommendations:

- Internal implementation of a system where data pipelines transfer all data sources to a data warehouse; At least all of the MOE's data, but recommended for all government agencies in Palau (ex. the Ministry of Finance, etc.); Connect Apache Superset or another BI tool to the data warehouse

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Ministry of Education
Republic of Palau

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I. About the Organization

Organization

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Some major functions of the Ministry of Education include the following:

- School improvement processes
- Curriculum development
- Student progress assessment and reporting
- Budget preparation
- Personnel recruitment, selection and management
- Teacher and administrator training and certification
- Community and vocational development
- Adult education initiatives
- Policy analysis, evaluation, and recommendations

The Ministry is also responsible for all matters pertaining to public education in the Republic. The organization is divided into two overarching bureaus, the **Bureau of Education Administration** and the **Bureau of Curriculum and Instruction**. The Bureau of Curriculum and Instruction has

two divisions, the Division of Curriculum and Instructional Materials Development and the Division of Instructional Implementation and Teacher Training. The Bureau of Education Administration contains three divisions: the Division of Personnel Management, the Division of School Management, and the Division of Research and Evaluation, along with support services that include IT and general administration. These last two units are the departments that have reached out to work with the TC in GC program.

Facilities

The Ministry of Education is in charge of 118 buildings totaling 340,000 square feet of space. These buildings include educational facilities as well as administrative ones.

The primary MOE office is located west of downtown Koror, opposite Palau High School. The first floor of the office holds some conference rooms, the server room and the office of the Minister of Education. The second floor of the building is divided into two sides based on the bureaus – curriculum and administration. The upper floors have cubicles for staff and offices for department chiefs, directors and receptionists. All offices and work areas inside the Ministry are air conditioned. There are six laser printers in the office, with two printers that work and four that need maintenance. The building parking lot has had solar panels installed since 2010 which theoretically provide up to 51 kW in electricity but are relatively unreliable in practice.

There are government-provided cars for the employees to carry out MOE related work and to visit schools in different districts, when needed. The Ministry also owns three speedboats for traveling to schools on other islands like Peleliu, Angaur, or Kayangel. There is a small maintenance department behind the Ministry that is in charge of maintaining all the cars, but boats need external servicing.

Each student is also given a personal tablet. Three schools in more remote areas are too far to reach the MOE's intranet, thus are not connected to the internet and have no computers.

Programs

The MOE manages 17 elementary schools and one high school. The high school and community college are located in Koror, whereas the elementary schools are scattered throughout the 16 states. There are 2 private elementary and 4 private high schools that run under a charter granted by the Ministry, but they are in charge of their own operations outside of a triennial Ministry inspection.

All the programs run by the MOE aim at improving the schools and the quality of education. For a list of past TCinGC projects see Appendix A.

In the past two years, students from the TCinGC program have been working on a requisition operation management application. Although not fully completed, the ministry has been using the working modules to aid in administrative work and budgeting. Finishing and polishing of the remaining modules is still of high priority, but this year, and of equal priority, we developed a student information system for the elementary schools and reporting capabilities for the MOE. In particular, these two developments are of importance because they directly contribute to the MOE's ability to understand student success and make internal and external reports efficiently.

Staff

The Ministry is headed by the Minister of Education, Sinton Soalablai.

Around 430 people are employed by and at the MOE, including the teaching and administrative staff at the schools. All schools have principals as heads, and three schools also have vice principals.

The primary client partners for this engagement are:

1. Edwel Ongrung, Administrative Services Manager - Edwel is in charge of Support Services for the Ministry. He is also the person responsible for server maintenance and managing all the technology related things going on at the MOE. We will be working with him to analyze the problem, discuss the feasibility of the solution, understand the compatibility of the solution with the existing software and hardware infrastructure. Edwel is well versed with sql and feels comfortable with Ruby on Rails, as per training he received during previous projects. He will be responsible for maintaining the project in the future.

Our project is two-fold:

1. Creating a student information system for elementary schools that tracks student performance and allows transcript generation.
2. Streamlining the reporting process.

The first part of the project will impact data entry staff who are responsible for inputting student data and generating transcripts. These secretaries and managers have access to a work computer. The second part of the project will impact employees in the Division of Research and Evaluation. DRE is currently responsible for generating reports. Currently, these employees use Excel spreadsheets to do each report individually. People who read the reports are the public, government leaders, and central office and school staff.

Technology Infrastructure

Although not the official operating system for the MOE, Mac OS seems to be widely used at the office. Most employees at the office have a Macbook or similar Apple computer.

The elementary schools have about 2000 Android tablets, 200 iOS tablets, and a small mix of Windows, Mac, and Linux desktops, for the students. This year, elementary school teachers each received a Macbook Air. The high school has most of the Windows computers. Principals and other Ministry employees use Macs, with some staff using Windows and Linux.

The connection of Palau to the international fiber-optic network two years ago has made using the internet in Palau the fastest yet. Access is now as easy as purchasing a card with an access code on it; there are wireless access points offering broadband-level speed (5 Mbps) throughout Koror that anyone can connect to after purchasing the card. The Ministry has also greatly benefited from the new fiber optic cable and recently increased the bandwidth of their connection. Each MOE campus (schools, office sites, and central office) has a WPA2 protected wifi. Each campus is connected directly to the internet (central office at nominally 80mb/sec and other campuses at nominally 10mb/sec).

The high school currently uses an evaluation management information system(EMIS), developed in past TCinGC projects.

Technology Management and Planning

Technology is managed across two units - one unit manages IT and support services and another unit within the Bureau of Curriculum and Instruction is responsible for managing instructional technology. The IT unit is responsible for the technology infrastructure and providing services and technical support to MOE users. The most prominent problems that the IT support team tackles are maintenance of equipment, mainly copiers and printers and network problems throughout the school system. Edwel serves as the head of IT and has three staff members working under him, Bal Ongrung, Aberlynn Ngirous, and Warren Fukuichi. Bal is the technician, Warren is responsible for the network, and Edwel is responsible for servers and backend services.

Bal mainly works on fixing hardware problems for laptops and replacing faulty parts. Warren and Edwel focus on keeping the servers up and running and fix any network problems that occur in the ministry and the schools. Together, the team is responsible for tackling IT related issues for nearly 2,200 students and 430 staff. The MOE also hires local IT vendors to help them with various projects and for maintenance of hardware.

The IT unit is also responsible for all the information security of the Ministry. All the PCs use a free open source antivirus system called Avast. However, any Macbooks (or personal laptops) do not have antivirus software downloaded. In order to block harmful websites and mitigate threats from incoming and outgoing network traffic the department relies on firewalls setup on the network servers. Though this is not relevant to our project's scope, it is also an area of critical and urgent need for the Ministry as Edwel has mentioned that they lack the skills.

Communication

Most communication at the office is carried out in person, with people walking to the office of the person they want to talk to or using phones to dial each others' extensions. All files and information are shared through email. Employees have emails ending with '@palaumoe.net' that they use for official communication. For faster responses, people text each other using iMessage as most of them have Apple computers. With the remote nature of this year's TCinGC project, communication between us and the client have shifted to Slack, Google Drive, Zoom, and iMessage.

The management uses reports to summarize the results of the year and each quarter. There are three main annual reports: Annual Performance Report (APR) , Statistics Yearbook, and Management Action Plan Evaluation Report (MAP Evaluation Report) .There are also four quarterly reports which are issued from every unit of the MOE. The APR has summarized information about budget allocation, expenditure breakdown, vision and mission of the ministry, information about personnel along with medium and long term goals. The Statistics Yearbook has summarized information about student performance and student data. The MAP Evaluation Report is created at the beginning of the operational year to describe what the MOE is going to do in the upcoming year, based on the data and targets met from the previous year's reports. Additionally, the ministry provides data to the UNESCO Institute for Statistics (UIS), that becomes part of the country reports.

The MOE's website continues to provide information for external parties; it also hosts an intranet server containing educational content for internal use along with some past reports and documents.

Information Management

Enumerated below are major information management systems that are in use by the Ministry of Education.

1. Expenditure Tracking Information System

It recently became a priority for the Ministry to better understand and track expenditure and student success. In having the ability to electronically track expenditure and student success, the MOE will be able to evaluate and report key performance indicators internally and externally to UNESCO and The United Nations with better ease. Spreadsheets and log books have been in use at the Ministry since the 1980s, so they became the de facto method of tracking expenditures as the MOE looked for a technological replacement. Attempts were made to use the Excel logbooks to figure out and provide evidence of teachers getting materials they needed, but it was prohibitively difficult to conduct and report summative evaluations for reports such as the APR or MAP.

Last year's project delivered a Ruby on Rails application hosted on the MOE intranet server that has four modules corresponding to the four defined functions of the MOE's expenditure process. Edwel mentioned that although implemented and functional, there is still work to be done to improve the functionality of the expenditure tracking system. Particularly, Requisitioning was completed, tested, and put to production by the previous team. Receiving was completed, but was not tested or deployed to production. Inventory was only partly wire-framed and reporting is still to be addressed. Edwel currently handles the maintenance of this project.

2. Student Information System - The SIS for the elementary schools is being completely redone as a part of this year's TCinGC project

Currently, both the high school and elementary schools have an online Student Information Systems (SIS), the result of projects starting in 2005 and fully up and running in 2009. This application runs in PHP with a MySQL backend. Both the high school and elementary schools' SIS's collect data. In the past, teachers in high school used computers in their department offices to enter student data and school staff in elementary schools with access to computers were designated as the data entry person. Now, each teacher has a computer to enter grades. This system is able to track gpa and absences, as well as create report cards. For elementary schools, this system is only able to track data. This data is used by the Division of Research and Evaluation at the central office to write quarterly and yearly reports. Edwel extracts this data by writing SQL queries and exporting the data to spreadsheets, which is processed by an expert in Excel to create the final report. Additional information about reporting can be found later in this section.

Edwel mentioned a few issues with the existing system. Primarily, there is no way to create a report card for elementary school students using the student information system. Creating these report cards manually can take several days as it is still a manual process. Additionally, this system does not keep track of other aspects of student information, such as residency, counseling needs, and daily absences. Finally, the system relies heavily on the user to input valid information, leading to several inconsistencies such as errors in spelling.

3. Reporting Information System - The reporting system is being addressed as the other part of this year's TCinGC project

Sitting on top of the data on student performance and expenditure tracking is the MOE's reporting process. The MOE is responsible for utilizing the data in these databases to construct standard quarterly or yearly reports. In order to get the data to write these reports, Edwel backs up the database, runs some SQL tests to confirm the accuracy of the data, and then runs SQL queries. Then, the data is handed over to an expert in Excel who compiles each report in its own spreadsheet. This process to complete the annual report takes around two weeks.

Edwel mentioned that an additional consideration with reporting is accuracy and relevancy of the data. As mentioned earlier, the existing student information data has inconsistencies due to the fact that the data is manually entered. In reporting, those who work with the data often find these inconsistencies and contact the school systems to confirm the error. However, instead of permanently fixing the error in the database, many times the error is just fixed locally in the spreadsheet for the report. Edwel mentioned that there is currently a process for fixing these inconsistencies properly through a database manager, but this process is rarely followed.

Business Systems

As briefly mentioned in the Programs section, the Ministry of Finance (MOF) is the agency authorized to budget and spend government funds. The MOE remains under the MOF umbrella, and is constructing more detailed data capture systems to support data-driven management.

Once the MOE's budget is allocated by the Legislature, all expenditure requests follow a specific process. Items are requested by different units and must be approved before a purchase order is issued. After the vendor fulfills the order, the items are picked up by Saburo (the receiving staff) and verified before he distributes them to their recipients. Inventory management used to have no formal system in place; after repeated failed inventory tests that once forced the Ministry to pay multiple audit exemptions costing up to $45,000 each, the MOE hired an inventory custodian and reports no issues since. This official, Adeline, maintains a master list of all assets within the MOE. Twice each year, she receives inventory lists from each unit (department and school) within the Ministry and verifies their status against her master list. If any items are damaged or were not delivered, she makes a note of this before exporting a list of all fixed assets (costing more than $5000) that she has her bureau's directors sign before forwarding it to the Palau Procurement Office for record keeping. This entire process is conducted by hand, resulting in a list of a few hundred assets that has to be manually verified twice every year. No greater analysis is done on these records, but they are constantly maintained by Adeline. The MOE also has its own inventory tracking system, that contains significantly less records and is more detailed than the inventory system used by the MOF. This tracking system is used primarily for assets such as laptops and tablets.

II. Student Information System

Motivation

The MOE currently implements a Student Information System (SIS) in its public elementary schools to track student biodata, enrollment, and grades. The current system was constructed in an ad-hoc manner and primarily serves the data gathering needs of the MOE Central Office and lacks the features necessary to address school level needs. There are two areas that need to be addressed:

lack of school level features, and difficulty of integration or scaling into a strategic system such as an Education Management System (EMIS).

The unmet school level needs which the MOE wants to address include:

1. The current system does not track standardised and special assessments scores such as IOWA, PERA, RSN, or other data points such as behavior, counseling, and discipline that could be useful for understanding and reporting student performance.
2. The current database has high inaccuracy and inconsistency rates due to limited data validation at data entry and lack of data integrity measures (eg., business rules, database normalization, etc).
3. The current system adds work to a teacher's workflow by adding a "report to SIS" step to the existing "report to Parent (report card)" and report to student file ("transcript and annual record").
4. The current system does not enable transcript or report card generation at the elementary school level. Instead, secretaries have to search through several paper documents to accomplish these tasks. This process can take hours per class and is highly manual.

Some of the unmet strategic needs such as EMIS which the MOE wants to address include:

1. Need for future maintenance, upgrade, and expansion. This requires that the app follows a model and programming standards rather than the ad-hoc nature of the current system.
2. Need for integration into an EMIS. This requires that the app design follow a model and programming standards.
2. Need for integration into a Data Analysis System (DAS). This requires that the app enforces data integrity and stores data in a database with an appropriate Entity Relationship Diagram (ERD).
4. Need be ready to migrate to a commercial SIS if ever the MOE finds it necessary in the future. This requires clean and accurate data and an ERD that accurately models the MOE's processes and workflow.

The systems (SIS, EMIS) that the MOE is focused on for this project are part of the MOE's data-based decision making and best practices efforts which are key components of the MOE's drive to improve its capability to achieve its mission.

Outcomes

On comparing several potential solutions, we decided on implementing a custom Ruby on Rails application to replace the existing student information system. In order to achieve specific outputs, a series of activities were performed. Over the course of 10 weeks, we:

- Collected all background documents and compiled a list of use cases in order to create an ERD that captured the data necessary for business processes.
- Created and verified a list of business rules that were implemented in order to ensure data integrity.

- Developed a Ruby on Rails application that allowed the management of student information. Some of the key functionalities of this application included:
    - Management of classes, enrollments/registrations, students, and academic years
    - Report card and student transcript generation
    - Batch processing of student grades based on gradebooks mandated by the MOE
    - Data validation
    - Authorization and Authentication - different views and functionalities based on the users role
- Model tests
- Cleaned and migrated the data from the previous system to the new system by normalizing the data and meeting with staff to fix inconsistencies.
- Moved the Ruby on Rails application to a server for deployment
- Met with MOE staff and Meyuns Elementary School staff in order to receive feedback and hold training sessions.
- Wrote supporting documentation on the ERD, business rules, data migrations, and application in order to provide support for future development.

Some of the outcomes and indicators that follow include:

- A clean and normalized database. Thousands of errors including misspellings and fallacious data were fixed. Because the application has strict data validation logic in place, incoming data will also adhere to a higher standard of integrity. MOE staff who work on reports will no longer spend up to two weeks fixing the same data.
- The normalized database will also be the starting point for reporting related data pipelines.
- An application that provides increased value to the secretaries of elementary schools. This includes increased efficiency in searching for student information and report card generation. Creating report cards now takes less than a minute instead of several hours.
- An application that provides increased value to the teachers of elementary schools. The previous system increased teacher workload by adding additional worksheets and steps to record student grades. The new system allows teachers to upload their worksheets in a slightly modified format directly.

On completion of this 10 week period, the application was deployed and used at Meyuns Elementary School. For the academic year of 2021, Meyuns will pilot this application and evaluate effectiveness and efficiency. Based on their experience, this application could be deployed to all schools in upcoming years.

Some risks to the success of this application include:

- Lack of local expertise with Ruby on Rails (the app is brand new and is in pilot at Meyuns, a situation which will require revision and maintenance).
- Lack of management support and follow through (the app requires changes to existing school processes and teacher workflow).

In order to mitigate these risks, extensive documentation on this application and data migration can be found in the handoff folder.

Recommendations

In order to ensure the long term success of this application, the following is recommended

- For the schools using the older student information system, it is recommended that any incoming data is pushed to the database with a flag. In the case other schools would like to use the system in upcoming years, it will be easy to tell what data needs to be migrated.
- It is recommended to link the schools and employees tables directly to the database from which the data was pulled. In doing this, crucial information will not exist in two distinct locations.
- A few auxiliary modules were not implemented. These include incidents, special education, socio-economic data, and residency. It is recommended to implement these modules in order to capture additional aspects of student information.
- Plans for maintaining and upgrading the app should be developed, especially addressing any issues of expertise with the app platform and technology.
- The MOE already supports the implementation of the new SIS. But it must be kept in mind that, because of the process and work flow changes brought by the new system, the support must be material and must be robust to alleviate all kinds of issues that should be expected (eg., lack of teacher technology literacy, resistance to workflow changes, frustration from lack of or delayed responses to requests for help, etc).

Additional specific recommendations can be found within the handoff folder.

III. Reporting System

Motivation

Borrowing from your scope of work document, describe the problem or opportunity that was addressed. Describe how this problem or opportunity impacts the mission of the organization.

Review the feedback comments you received on your scope of work, and update the justification to make the argument stronger and clearer.

The MOE is responsible to putting out several reports every year, the main ones being:

- Annual Performance Report
- Statistics Digest/Yearbook
- MAP Evaluation Report
- UNESCO Sustainable Development Goals 4 Report
- UNESCO Institute for Statistics (UIS) Report

The process has moved from being done manually to semi-manually. In past years projects, measures have been put in place to collect data for the MOE. For example, the SIS that the high school uses. Currently, this data is then put into excel spreadsheets for an individual to use to perform analysis on and get the numbers for the above reports. Edwel has noted that the current process lends itself to the following problems:

- (Main Problem) The numbers for the reports take a really long time to be generated; being accountable and transparent requires reports and data to be available immediately to the appropriate stakeholders.
- (Sub Problem) Since reports numbers are calculated by individuals in excel spreadsheets, the MOE doesn't have a history of the reports that they could audit if anything goes wrong, or if that individual leaves the organization, or has deleted or lost their files.
- (Sub Problem) Data integrity is a problem. Often data errors are found and corrected during the analysis process by the individual. Such corrections are not made back on the source database. The people who do reports end up having their own versions of corrected data which will differ from the database source and from each other.
- (Sub Problem) Report accessibility, while less of an issue, can sometimes cause issues. This is partially solved by possibly depositing the reports in a web repository but it would be better if a system exists that generates the reports and automatically archives or stores them in an accessible way.

While report accessibility, history and possibly data integrity are problems that could perhaps be solved by requiring the individuals who do the reports to upload their data and excel spreadsheets to something like a Google Drive folder or a Github repository for shared access, the main pain point that our solution will try to tackle is the time it takes to generate the numbers for the reports.

Our original solution idea was to use a tool called Apache Superset. Apache Superset is an open-source business intelligence web application that allows for a direct connection to databases, has a SQL editor and the capability to create data visualizations to be added to dashboards for easy access to relevant numbers. Other solutions like Tableau and PowerBI cost money which the ministry doesn't have the budget for or don't connect directly to the databases. Alternatives to Superset are Redash and Metabase which are both free but Redash requires extensive SQL knowledge and Metabase only allows for basic SQL, opting for a 'simple question creator' to generate dashboards and visualizations.

After spending more time at the ministry, we realized that the problem with report generation was a much larger problem than just having a business intelligence tool to connect to the data and do calculations. We realized what the ministry needed was an entire Data Analysis Stack (See recommendations section below).

Outcomes

Activities and Outputs:

- A centralized place for information was needed, so a MOE WordPress site was created that I believe Edwel and those after him will be able to maintain
- Researched Business Intelligence and various different tools; Chose to use Apache Superset and tool was successfully installed on the MOE's server; We were able to connect Superset to the old EMIS database as well as Vrinda's new SIS; Research available on the WordPress site

- Research was done on Data Analysis Stacks and why they would be useful to implement for the MOE; Research available on the WordPress site
- Presentation to the Division of Research and Evaluation (DRE), which handles reporting for the MOE, given to introduce the concept of reporting as an entire system and not an individual task. This included an explanation of ETL(Extract, Transform, Load), DAS(Data Analysis Stack) and BI (Business Intelligence); Presentation slides, transcript and video recording of the presentation given to the DRE can be found on the WordPress site
- Demonstrated the capability for Superset to create tables and charts for the Statistics Yearbooks using data available from the MOE (primarily from the SIS pipeline); Previous versions of this report were pdf documents, but after seeing what Superset was capable of Edwel decided that those reports could take the form of public dashboards within superset; Note: The embedding slices(graphs and charts) feature of Superset was working at one point, but unfortunately broke and couldn't be fixed -- documentation for the issue was followed to no avail
- Dashboard of example graphs for the Meyuns School to demonstrate how Superset might be used to the schools' and the teachers' advantage in helping their students
- Documentation on how to navigate Superset (run a SQL query, make a line graph, etc.); Available on WordPress site

Outcomes and Indicators:

- DRE is now aware of DAS concepts and reporting as a system. They have had a discussion about them, which included talk about the feasibility of implementing such things at the MOE
- The time it takes to generate a report from data in the connected SIS database takes a couple days at most compared to the weeks the same reports took before
- The new WordPress site increases ease of sharing materials within the MOE and with future TCinGC projects that might follow and build off our work -- things like the DRE presentation are available via the site
- If the DRE and MOE management decide to implement a DAS for all their data, the DAS and BI tools reports, available via the site, will provide them with a starting point and basic understanding of the concepts
- After demonstrating to the teachers at the Meyuns school the sort of graphs that could be generated with Superset, some showed interest in using that to help monitor their classes and students

Configuration of Apache Superset:

Superset is installed on the MOE server and we were able to access it via the IP address and port. Superset runs in a terminal on the server and if the terminal ends, the superset web application goes down. The only configurations changed were in the attempt to allow for iframe slice(specific visualizations) embeds in web applications like our WordPress site. In superset's config.py file, located on the server(we also tried making a superset_config.py file and putting it in the PYTHONPATH with the changes we wanted like the documentation suggests, the config file was read, but to the same end effect as follows): the PUBLIC_ROLE_LIKE_GAMMA flag was set to True to try and allow for non-logged in users or users without superset accounts to be able to see the slices by giving them the same privileges as the GAMMA role(changed within the superset UI) and giving them access to the data source; We also ran into a problem with missing CSRF tokens and following GitHub issues changed SESSION_COOKIE_SAMESITE to None,

SESSION_COOKIE_HTTPONLY to False and WTF_CSRF_TIME_LIMIT to None. The fixes worked for some time and then stopped working. We were unable to find a solution and so we shifted from embedding to making dashboards to serve as reports.

Risks to Sustainability:

- Superset requires some SQL knowledge that Edwel has, but it's not certain that those to follow him will
- Superset has poor support and documentation
- Superset is only as useful as the information it has access to, so to be used at full capacity it requires the MOE to view reporting as a system and put in place the necessary parts of DAS

Recommendations

Recommendation I:

We believe that it would be beneficial to the MOE to implement a DAS system. A DAS is a systematic approach to the reporting process and it consists of 3 components: the data pipeline, the data warehouse and data analysis.

The MOE has an abundance of data sources, which is anywhere data resides, whether that be in hard copy forms in cabinets at schools or a secure computer at a private school. These data sources don't just come from the MOE, for example the hard copy of the Ministry of Finance's (MOF) Accounting Data is a data source as well. The data pipelines are how all those different data sources get from where they are stored to the data warehouse.

At the current, most data sources are hard copies which have to be manually entered into spreadsheets and that data is generally not shared or made easily accessible to others who might need it. Establishing the pipeline, negotiating for the data, entering data, essentially bringing all the data sources into the MOE under the current process, takes days to accomplish and everyone does the data collection process separately which is very inefficient, as most of the time it's redundant work

A data warehouse is a singular place for gathering all the data from different pipelines. Currently the MOE does not have this component so data remains in their respective sources. If the MOE did have a data warehouse, all data pipelines would connect to it and in order to get into the warehouse, the data from the pipelines would have to be extracted, transformed which means cleaned, verified, etc. and then loaded and stored in the warehouse for easy access when it comes to analysis or reporting functions. This would mean that an analysis worker would just have to make simple queries to the warehouse to get any and all clean and accurate data they needed for analysis and report generation.

The current reporting workflow: negotiating for access to data, collecting the data, cleaning the data and then the data is analyzed and a report is generated. The negotiating, collecting and cleaning steps account for 80% or more of the amount of time it takes to produce a report.

With a DAS, the reporting workflow: data would exist in multiple sources or places like with the private schools or the Early Childhood Education institutions or from the telephone and communication hard copy bills and then the difficulty is establishing a pipeline that ensures that all data is extracted, transformed and loaded into a data warehouse just once. Then whenever there is a report, analysts query from the warehouse for all necessary data, analyze the data and generate the

report. This process becomes more of a system and not just a task with steps, significantly reducing the amount of time it takes to generate reports.

As these components don't currently exist for all of the data the MOE collects and uses, the data pipelines and the data warehouse are internal things that would have to be implemented and monitored/maintained. But the steps of negotiating, collecting and cleaning the data are akin to data pipelines and a data warehouse and so those processes are things that the MOE already does. Implementing a DAS would merely make reporting an entire system that can eliminate redundant work and therefore make it more efficient.

We've spent the summer implementing the data analysis component of the DAS. BI tools are used to transform raw data into meaningful visuals, reports, dashboards or information in order to provide context for decision making. Right now, Superset is only being utilized to calculate numbers and make graphs for reports, but it is also possible to use these kinds of tools to help measure and monitor KPI's and not just for the MOE but also for specific schools too. Implementation of a full DAS, would allow the MOE to use the Business Intelligence tool we've implemented, Apache Superset, to its full capacity and increase their reporting capabilities.

Reports would take days, not weeks to produce and any information about the functioning of any part of the MOE - all the schools, specific schools, the budget, etc. -- could be at MOE's fingertips.

We recommend the implementation of a DAS for at least the MOE, but the recommendation is certainly not limited to the MOE, as other government agencies would also most likely benefit from such a system.

A more in depth explanation of DAS and BI tools is available on the WordPress site under the post titled "DRE Session 07/23/2020".

Recommendation II:

Currently, the thought is that the DRE will produce any graphs/reports that the teachers want, but given the number of teachers who will be using the system and the number of students, we acknowledge that such a system is inefficient. Given that the teachers at the Meyuns school showed interest in Superset's capabilities in displaying trends of their classes and students, we recommend that training be developed to teach teachers to use Superset.

About the Consultants

Vrinda Gupta is a recent Carnegie Mellon University graduate with a degree in Information Systems and a minor in Computer Science. Come the Fall, she will be starting her career as a Software Engineer at Amazon.

In the coming school year, Caitlyn Low will be finishing her senior year of undergrad with a degree in Information systems.

Due to COVID, both consultants were not able to physically be in Palau for the TCinGC program. It is their wish that one day they will get to visit Palau and meet Edwel in person.

Appendix A. List of past TCinGC projects

	Past MOE TCinGC Projects	
Jon and Matt	2005	Customised and set up an open source SIS system for MOE. Worked, but needed more customization so he taught the MOE PHP and MySQL. Project was scrapped after a year. MOE tried to build own using skills taught. Built the server infrastructure, taught MOE how to maintain the services and servers. Infrastructure still in use today (with appropriate modernization, etc).
Edmund and Jasmine	2007	The Palau High School (PHS) Student Information System (SIS) built with MySQL backend and MS Access front end. First user managed website built using Drupal. Added all of MOE content and customized Drupal to work the way they wanted. Site not in production as of this report.
Tom and Yixin	2009	Built an online app to facilitate cleaning and capturing standardized test data and reporting the results using PHP. It tried to mimic the exact workflow that MOE staff were doing manually. The app was not put into production, but code reused in other less ambitious projects.
Andrew and Yuki	2014	(Project still in-progress, not fully completed) Established device management capabilities using Apple solution, network was set up, established project management practices, mitigated financial audit issues, established IT governance.
Joe and Sam	2015	(Project still in-progress, not fully completed) PHP app for capturing electricity consumption data and report consumption rates. Another PHP app for tracking mobile devices assigned to students.
Ryan	2016	(Project still in-progress, not fully completed) android app for teachers. Teachers were provided Samsung Tab tablets.
Daniel	2017	(Project still in-progress, not fully completed) Ruby on Rails app for teacher evaluation system.
Ameeshi	2018	(Project still in-progress, not fully completed) Requisitioning App, assessed the needed changes to the 2017 app.
Jeevika and Pavan	2019	(Project still in-progress, not fully completed) New Requisitioning App with new ERD and front end. Taught the MOE Ruby on Rails.