Business Intelligence Enabled Framework for Nursing Practicum Placements and Reporting

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***Abstract*—Practicum placement for nursing students is a complex process due to the hierarchical nature of steps involved, evolving underlying data and intricate business rules. The process is further complicated when facilities are sparsely located and students must travel for their practicums. We have applied business intelligence tools to build a framework which uses an integrated web-based approach to address these issues and provides interactive web forms for students, practicum coordinator and managers; in addition, a reporting dashboard with drill-down and drill-through capabilities is provided for analysis and reporting. The proposed system reduces the effort needed for managing practicums, provides embedded controls to mitigate errors such as over-subscribing and duplications, auto-generates notifications, and provides readily accessible reports with up-to-date information.**

***Index Terms*—business intelligence, analytics, nursing, practicum placements**

I. Introduction

Clinical placements give students the opportunity of putting theory into practice [1]. In order to provide enhanced education for future healthcare professionals, students are exposed to live clinical environments. Students develop practical skills under the supervision of practicing clinicians and must emphasize on patient safety which is a growing consideration in clinical environments. During their clinical practicums, students also learn the organizational structures and processes prevalent in healthcare environments. An effective clinical experience is likely to boost the student's career and improve the quality of service in the healthcare organization [2]. However, due to progressing popularity of the nursing discipline, coordination of the required hands-on experience is becoming increasingly more difficult and time consuming [3].

An ideal practicum placement is one which places the nursing students in their preferred clinical unit. The availability of clinical sites, the specific course in which student is enrolled, and students' preferences must be taken into account when establishing each student's clinical practicum. Unfortunately, no integrated system exists which provides a holistic approach to the practicum placements. In most cases, practicum coordinators have to determine the placements of students by manually utilizing spreadsheets with limited structure and even less capability for analysis. We have applied Business Intelligence (BI) tools and techniques to design a comprehensive solution which encompasses various aspects of practicum placements from registration and availability to auto-generation of email notifications. Designed to be used by the practicum coordinators and managers, the system aims to streamline the clinical practicum process and provides tool for collection, analyses and reporting of data. The system has been successfully implemented in an institution which spans multiple campuses located in five different cities and offers three undergraduate nursing programs. The proposed system has encapsulated data into a single relational database which serves as the backend for data entry and reporting components. By integrating the business logic of the clinical practicum process into a dedicated system, the complexity of managing and coordinating these placements has been significantly reduced.

II. Related Work

A critical concern is to develop an organized student placement process that encourages clinical placements preferred by the student. Though similar applications exist in other areas, there has been very little work done towards an integrated solution for nursing practicum placements. This could be attributed to the complex business rules, scope of the placement, and lack of standardization. In comparison for instance, application and matching services for residents, medical students and medical schools is accomplished by a much more structured service provided by Canadian Resident Matching Service (CARMS) [4]. CARMS uses the MATCH Algorithm [5] which utilizes rank order lists submitted by both applicants and programs.

In BC, the British Columbia Academic Health Council known as BCAHC (formerly known as the Council of University Teaching Hospitals, COUTH) [6], was designed as "a unique and major strategic forum to facilitate effective and efficient collaboration at the interface between health care and post-secondary education sectors" [7]. One objective of BCAHC is to research on the concerns and capabilities of clinical placements for health science students. Moreover, BCAHC proposed a province-wide database system to administer student clinical placements [8]. As a result of

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BCAHC investigation, a Canada-wide system was introduced to evaluate and coordinate health science student placement. HSPnet (Health Sciences Placement Network) encompasses the process of placements from initial application to evaluation of qualification requirements leading to acceptance or rejection of the application. Also, it brings the ability of communication in order to locate the clinical rotations in the entire country [9]. However, although HSPnet is a platform for identifying availability and making placements, it is not a complete solution for coordinating placements and recording/presenting all associated details at the institutional level. Thus, HSPnet is not a tool for monitoring or specialized analytics. Robyn Nash et al. proposed a collaborative practical model of clinical placements for final year undergraduate nursing students. The findings indicate improved performance of students who are placed in a positive and supportive clinical learning environment matching their preferences [10].

The Feik School and a software development company built a web based system to record their student's success in pharmacy practice experience. The system consists of three parts: RXportfolio allows students to create their profile for their professional development; RXoutcomes allows to track and report on student progress; and, RXpreceptor provides site, student details and supervisor management [11]. RXpreceptor also offers hours tracking, student evaluations, externship scheduling management and student requirements and immunization tracking [3].

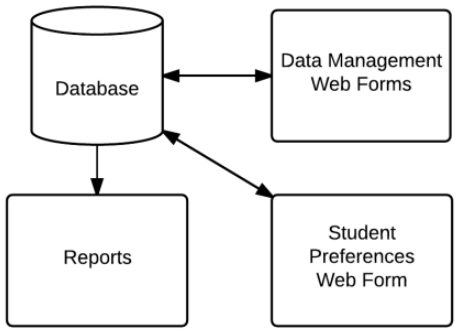

Figure 1. Components of the proposed system

III. METHODOLOGY

A fundamental challenge in designing a viable solution was the integration of data from numerous flat files and modelling the relationships between different components of the system. Business intelligence is a powerful technique to integrate and analyze data from disparate sources. Microsoft SQL Server 2012 [12], the accompanying Business Intelligence Studio and ASP.net framework [13] have been used as the underlying platform to integrate data; ensure data consistency and isolation; deliver reporting and analysis tools. The underlying data of the proposed system is stored in a relational database consisting of approximately 30 tables.

A high-level interaction diagram of the proposed system is shown in Fig. 1. Users interact with the system through the following components: data management web forms, reports, and the student preferences web form. Data is managed by the practicum coordinator through a web form application that provides validation on all newly entered data and the ability to search through and edit the existing data in the system. The reporting component delivers focused aggregations and drill-throughs of the underlying data. The data entry and reporting components have been designed to provide two contrasting perspectives. The data entry component offers the ability to easily navigate and modify the underlying data while coordinating practicum placements, whereas the reporting components focus on providing greater insight through more advanced reports. A nursing coordinator can open the data entry and reporting components in separate windows and use both tools side-by-side. The end-user interfaces have been implemented so that they are easily accessible through a standard web browser, and require no installations on the client's computer.

The entire practicum placement process consists of inter-related steps some of which can proceed concurrently whereas the others have precedence constraints due to the hierarchical nature of underlying data (Fig. 2). For example, a practicum course must be properly set up and students registered in the course before students can have the opportunity to indicate their preferences and special circumstances. Once student registrations are uploaded, either using the bulk loading interface or one at a time, students can use an authenticated interface to enter their preferences and requests for special considerations, if any. Simultaneously, the practicum coordinator updates the units and preceptor information as it becomes available. Similar dependencies exist for communities, sites, and units. By enforcing these constraints during all data entry and modification, the system provides data integrity and consistency throughout the web form application.

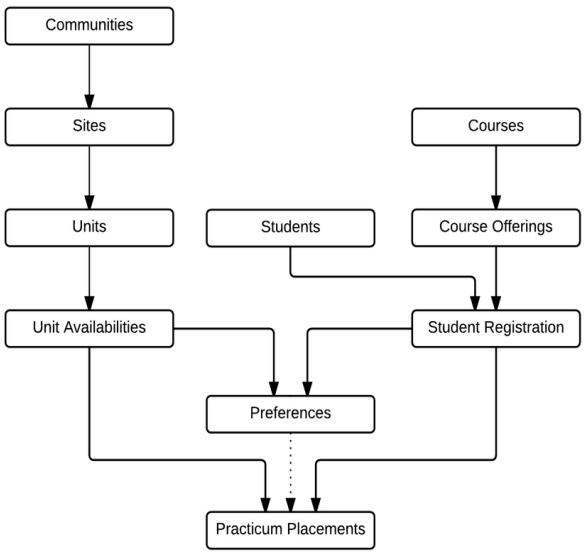

Figure 2. Data entry precedence constraints

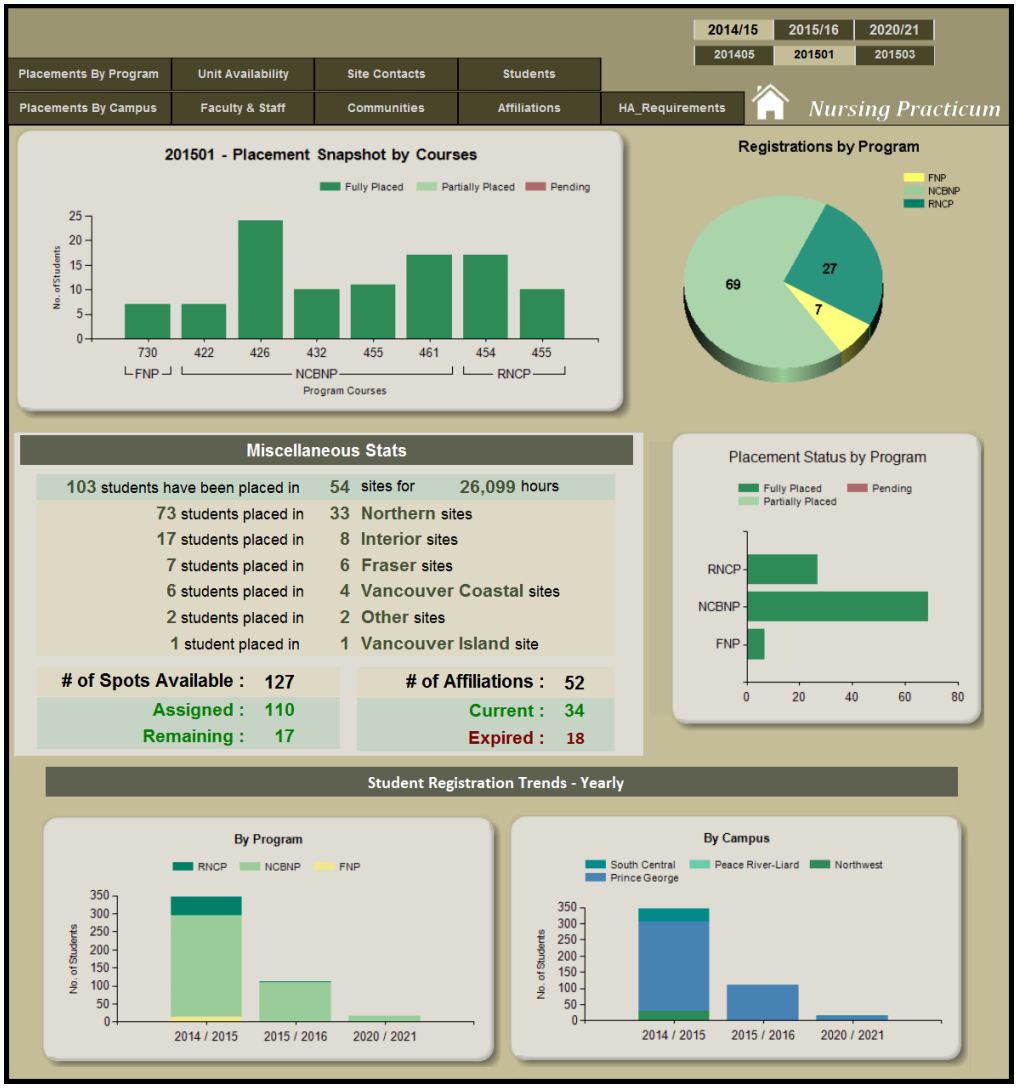

Figure 3. Main Dashboard

IV. Data Visualization

Reports provide visualization of the underlying data and are intuitively designed to guide the practicum coordinator through the placement process, and to inform managers of aggregated results. These are further augmented by drill-down/through sub-reports, tooltips and user-friendly navigation. The reports are tightly integrated with web forms in such that any information entered/altered is immediately reflected in the reports.

A. Dashboard

The main landing page displays the dashboard under a header which provides tabs for interactive navigation (Fig. 3). The dashboard provides an overview of key performance indicators (KPIs) [14] and presents aggregated information on various metrics for the selected session of academic year. The tabs allow user to switch/drill between different categories such as Placement by Program or Campus, Unit Availability, Faculty/Staff, Communities and Health Authority requirements. Placement snapshot by courses provide a breakdown of number of students fully placed, partially placed or pending within each program. Further placement details including preferences, requirements, and immunization records can be reached by clicking on the specific course. Other statistics include available and assigned spots, and affiliation agreements in place. Historical information and yearly trends are also shown.

B. Unit Availability

An inventory of units available for placements related to a specific course evolves over time. As availability of units and preceptors is confirmed by the coordinator, this information is entered through web forms and can be readily seen in the reporting module. It is extremely critical that units do not get over-subscribed. The Unit Availability report provides visual colour-coded cues to this effect (Fig. 4), where green, red and yellow represent units filled, overpopulated and available, respectively. Each unit can be further drilled down to see detailed information of students placed in those units, their

placement hours, program and course information, student placement details and more.

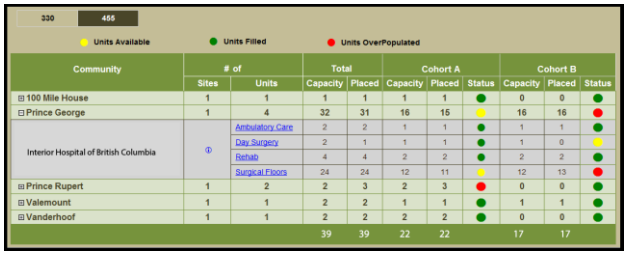

Figure 4. Unit Availability

C. *Placement by Program/Campus*

Placement report can be viewed by program or by campus (Fig. 5). It displays course information including total number of student registered, completely placed, pending, partially placed (in case of split placements) and over placed. The courses can be further clicked to generate a sub-report with detailed course information, students' placement details, preferences, immunizations, and list of students yet to be placed. In another drill down report, user can also see whether the student has met the requirement of the health authority in which he/she has been placed.

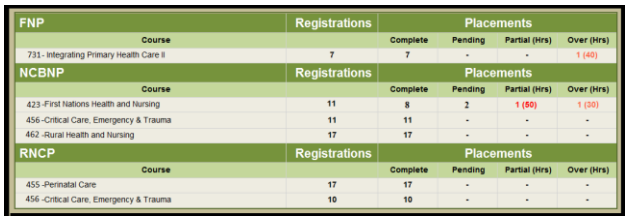

Figure 5. Placement by Program/Campus

V. Data Collection

The web forms provide an interactive way of entering data using constraints to ensure data integrity, and providing supplemental information to assist with completing the form. A total of approximately twenty forms were built using Microsoft Visual Studio ASP.net and C# [13]. All forms are accessible through a primary interface. Due to space considerations, we describe two key web forms in this paper.

A. *Practicum Placement*

The placement form (Fig. 6) provides the entry point for specifying details of a student's clinical practicum. It is designed to streamline the placement process by pre-populating data fields and seamlessly providing supplemental details and consolidated information from all previously completed practicums. This information includes student's preferred cohort, home campus, special requests, required placement hours, availability of clinical units, and practicum start and end dates. To ensure that the capacity of units within clinical sites is respected, this form provides features that disallow placements which exceed the available capacity of a unit. Once an available spot is assigned, it immediately updates the database thus making it suitable for multi-user environment. The placed student is also excluded from the drop-down selection list. Additional information emphasizes student's historical placement details, such as whether or not a student has previously travelled for a practicum, or was not given their first preference for one or more previous courses. This saves the coordinator from having to manually investigate the placement history for each individual student. Finally, new preceptors can be assigned and available units added without leaving the placement form. In summary, this web form is highly interactive and provides enough information to make an informed decision on the most suitable placement location for the student. The editing feature of the forms includes seamless updates to available units when student's placement is changed from one unit to another.

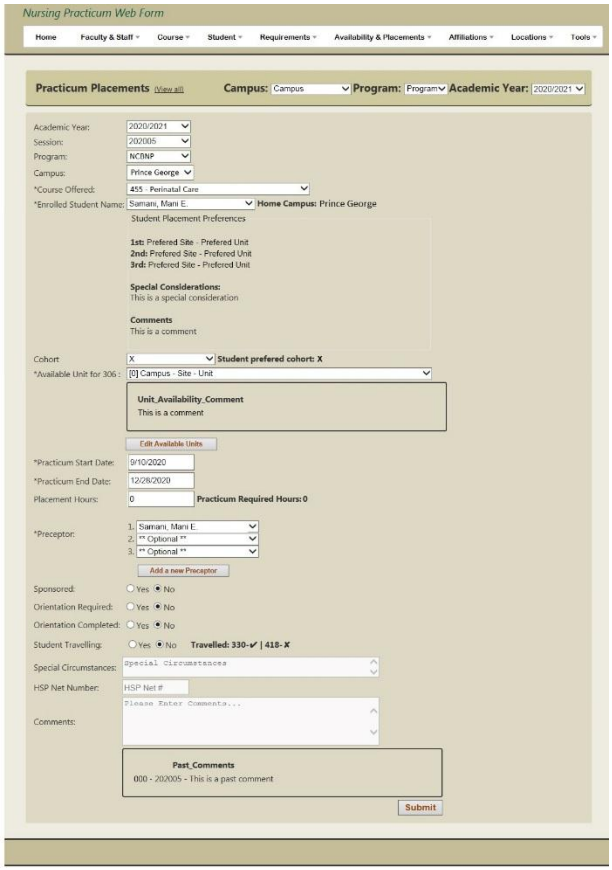

Figure 6. Practicum placement web form

B. *Student Preferences*

An authenticated web form allows students to submit their preferences and request special accommodations, if any. The preference choices presented to the student are derived from the underlying data in the system. The main advantage of a dedicated interface is the acquisition of student preference data that is logically consistent with the existing data in the system; this is then used to populate information blocks at the time of placement.

C. *Email Generation and Data Upload*

During the practicum placement process, emails are sent to students, as well as preceptors and managers of clinical sites. Through the email generation user-interface, a coordinator can auto-generate and send various types of

emails. Emails sent to the students contain details such as: placement location, date range, hours, and the contact information of their placement preceptor. Emails generated for the preceptors contain contact information of assigned students and the associated placement details. Another type of auto-generated emails produces recognition letters for preceptors and site managers. The coordinator has the ability to edit the generated emails before sending them to the recipient, and emails that have been previously sent are flagged as such. By pulling up-to-date placement information directly from the database and auto-generating the emails, this tool saves immense amount of time considering that hundreds of emails must be sent every semester.

Finally, in order to simplify the time consuming task of data entry, a one-click bulk loading feature was created to efficiently upload student and associated course registration data. SQL Server Integration Services (SSIS) [12] was used for this purpose.

VI. Conclusion

The inherent complexity of nursing practicum placements makes both coordinating and managing all activities quite challenging. We have developed a Business Intelligence enabled framework which significantly reduces the effort to manage the entire process. The system is highly interactive, intuitive, user-friendly and less error prone. Though there are separate modules for students, placement coordinator and managers, they all interact with each other seamlessly. The added functionality of auto-generating notifications for students, preceptors and facility managers together with ability to bulk load student and registration data makes it even more efficient. The affiliation agreements with various clinical facilities and contact information are also maintained.

The nursing practicum placements are also unique in the sense that these occur multiple times during the student's program, the underlying data continuously evolves and a large number of components need to work together in specific sequence. It should be noted here that, unlike CARMS, this is not an automated matching process due to the interactive nature of the problem and high number of dynamic constraints.

An obvious direction to extend this work is to interface with all entities involved including the health authorities and clinical facilities. The developed system can also be extended to serve as frontend for HSPnet.

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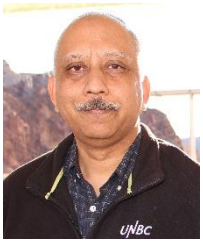

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