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Technology, Infrastructure, and Inter-Institutional Teaching and Learning Goals:

Toward the Development of Standardized Learning Management Systems

(September 2013 Update)

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Background and Purpose

In response to growing interest from members, the Group on Information Resources (GIR) organized the GIR Educational Technology Summit on January 10, 2008. This summit was designed for educational technology leaders from medical school and teaching hospitals to come together and begin a national conversation on infrastructure and technology standards around medical education technology. Three exploratory groups were commissioned to focus on areas where availability of technology standards was limited and presented challenges to design, delivery, and sharing of content: virtual microscopy, efolios, and learning management systems (LMSs). From this summit, a group of participants volunteered to develop a best practices guide on LMSs to support medical education.

Later that year, the Learning Management Systems (LMS) Work Group published *Technology, Infrastructure, and Inter-Institutional Teaching and Learning Goals: Toward the Development of Standardized Learning Management Systems.*

In the years since, the GIR Education Technology Work Group concluded that learning management systems (LMSs) have evolved to a point that an update to the original guide was merited. The 2013 Learning Management System Working Group was established to update the guide to reflect current and emerging trends impacting the technology.

This 2013 version of the guide features their updates.

Introduction

An LMS is a system that acts as a repository for educational course content, assesses knowledge (through use of assessment tools), and tracks individual learner or employee performance with the goal of identifying the progression toward organizational goals. LMSs vary in their features and functions. However, one of the main purposes of an LMS in an educational setting is to collect an individual student's grades and track progress throughout a course.

Typically whether created by the institution or commercial vendors, LMSs include a standard set of tools: quiz and survey capability, assignment sharing, discussion forums, grade books, reports, announcements, wikis, and portfolios. These features are, in most cases, sufficient to support the needs of general education.

LMSs are used at all levels of education (K-12, undergraduate, as well as professional education) and reflect the most common "one instructor, many students" educational paradigm. However, commercial systems do not fully support medical education as they are not designed with medical education in mind. University supported LMSs generally follow a semester-based course structure, putting it at odds with the typical medical school academic calendar structure. Additionally, the tracking of the educational experiences over multiple periods, with the many instructors and assessment methods that are required to acquire competencies are not well managed in these systems, nor is the tracking of competency attainment available in most commercial LMSs. Moreover, for institutions that provide an integrated medical curriculum, LMSs fall short as communication methods between courses in most LMSs are not well developed, making it difficult to track students or share content across courses. Furthermore, while many LMSs offer assessment through quizzing features, none of the commercial LMSs offer robust examination features, particularly for "high-stakes" exams required in medical education. Most often, a supplementary exam solution will be required to facilitate "high-stakes" exams.

This guide will cover some of the most important elements of an LMS as they relate to medical schools.

Learning Management System Work Group Vision for the Future

LMS content should be accessible from home, library, institutional computers, and mobile devices using any modern Web browser or app. It should further be supported by sufficient IT and network resources so that students and faculty can make broad use of these technologies. Security must be kept up-to-date, and daily backups must be ensured. An after-hours help option should also be available.

The ideal LMS should contain all academic information, including course materials, assessments, digital course assets, enrollment, and grade data. It should be able to track student participation, such as in discussion forum and patient encounters, and competencies. It should also utilize the currently available collaborative, interactive, networking and social tools of Web 2.0, such as blogs, wikis, and web conferencing. It should also allow for a seamless connection to an institution's student information system (SIS) portal and AAMC curriculum portal. While many schools seem to have most of these available through a combination of multiple systems, no single commercial LMS has been identified that includes all of these components. Furthermore, there are serious challenges to integrating the various components, which include hardware and software compatibility, identity management, interoperability among various platforms, and authentication policies. Persistence is another major issue. Technology changes so quickly that it is important to use technology that will likely be around in the long-term, so it would be profitable to understand the ideal LMS as a portal from which choices of tools, including third party options, could be plugged in with pass-through authentication. Ultimately the LMS should be transparent and fully integrated into the infrastructure of the entire educational system (e.g., access to grades, financial aid, etc.) within one password-protected logon.

Contents

I. Basic Principles

There are basic principles of any LMS that are specific to medical education.

1. All students must retain access to all courses they have already completed in Medical School for all years of their medical schooling. (Access in this discussion is defined as the ability to enter, participate in, or use materials associated with a course.)

The basis of any LMS should be to improve student learning experiences, accommodate a variety of different learning styles, and allow more effective teaching. As medical educators, we seek to graduate physicians with a lifelong learning habit. By allowing our students access to all of the materials that they encounter during their medical school curriculum, we foster self-directed exploration of future topics related to the current curriculum.

Access also permits students to re-visit the science of medicine when it becomes important clinically. For example, in their clerkship years, students taking care of patients with increased ammonia levels may wish to revisit the relevant materials presented in their first two years on the urea cycle. We know that it is impossible to remember all the details that are part of pre-clinical teaching. By reviewing material previously encountered, rather than starting again with information presented in a different format, there is repetition to aid in retention.

Providing students access to course materials across the four years of medical school can be accomplished in three ways: Archive Course Mode, Update Course Mode, and Extended Update Mode.

First, course material can be archived for the specific cohort (graduating class) of students so that the students have access to the course material that was provided the year the student was enrolled in the class. This mode will be called the **Archive Course Mode** for purposes of this discussion.

Archive Mode	Comments
Access	Students have access to the course that the student actually completed
Process	The course and course material for a class are archived upon course completion.
Advantages	By segregating the current and archived courses, the management of the release of sequenced content is alleviated.
	Assessments can be used as a review tool for past students and as an evaluative tool for current students.
	The current course can have content released on a schedule while the archived course can have all material available for review.
Disadvantages	This mode does not provide updated content unless a process is implemented to keep the archive content current.
	Updating archived content can become problematic when significant areas of the course have been modified.
	The archived course material mode does not facilitate collaboration between current and past students, since the current course and the archive course are segregated.

In a second mode, called **Update Course Mode**, student cohorts have access to the current year's course material for all the courses the students have completed and those in which they are currently enrolled. That is, students have access not to the materials that were unique to the years they were actually enrolled in the given courses; rather, they have access to the materials that are being presented in the current year to the current students. In this way, all students have access to updated content in all courses.

Update Mode	Comments
Access	Current as well as past students have access to the same course. Allows current and past students access to the updated content within a course.
	Processes need to be implemented that allow past students to review all content regardless of release sequence.
Advantages	This mode facilitates collaboration between current and past students.
	The assessments in the updated course material mode can be used as a review tool for past students by allowing them access to the assessment module in a self-check capacity. Current students would be allowed access to the assessment module on a predefined schedule and would receive grades for the assessment.
Disadvantages	There is a potential issue when a significant area of a course is updated from one year to the next. The issue is related to supporting past students in the updated content.
	The release of sequenced content (e.g., PBL case, case study, etc. where when engaging with the content the first time, having information out of sequence interferes with the intended learning opportunities), becomes an issue in the updated course material mode. Current students would still see sequenced content released on a predefined schedule.
	In allowing past students access to all sequenced content collaboration would need to be moderated in order to insure the integrity of the sequenced content.

The third mode, **Extended Update Mode**, is similar to the Update Mode in that current materials are always available to students. It differs in that students have access to materials in future classes, not just current and completed classes. Although this mode offers a strong advantage in completeness of materials, the process and disadvantages are the same as the Archive Mode.

Extended Update Mode	Comments
Access	All students have access to all current course materials regardless of when they occur in the curriculum.
Advantages	Fosters self-directed learning and encourages review of previous material.
Disadvantages	Display of any content that is designed for incremental release.
	Increased cost if a commercial proprietary system is used.

The purpose for allowing students to retain access to course material is to facilitate the review process for students and to promote collaboration and interaction through horizontal and vertical integration of student learning within the curriculum. The purposes for allowing students to access future materials are to promote familiarity with the broader context of learning, encourage self-directed learning, foster serendipitous learning, and reinforce vertical integration.

In order for students to retain access to all courses across all years, security will require that students be identified by graduating class cohorts. The cohort model would need to be supported as either a role or group in the LMS security model and be supported by the student information system with which integration is common and enrollment is controlled. This support would also include a process to keep the cohorts up-to-date. These cohorts would be used to provide access to the appropriate course or course content regardless of the mode utilized.

Within the LMS, the cohorts would have access level determined by defined roles. These roles would be used for faculty and staff as well as the cohorts of students. These roles include but are not limited to:

- Active Student
- Auditing Student
- Past Student
- Instructor
- TA
- Administrator(s)

These roles in the cohort security model of the LMS would be used to deliver sequenced content to an active student while allowing all access to a past student. In the same way, current students would have access to the assessment module for graded exams and quizzes while past students would use the assessment module for self-evaluation (in some cases, e.g., "high stake" assessments would be restricted and have additional security features and would not necessarily be available for self-evaluation purposes).

In both the archived and updated course material modes, additional support for dealing with the various cohorts will need to be provided. Support will also be needed for past student cohorts and for dealing with the updated or new content areas. In the archived material mode, support would be needed for updating course material. Within the updated material mode, additional support would need to be identified for:

- Updating course material
- Updating cohort membership
- Moderating activities for collaboration activity modules

The persistence of course material in the archived course material mode is maintained within the archived class. With the update course material mode, the persistence is maintained by updating current course content for all cohorts. For the updated course material mode, persisting content across four years of student cohorts presents potential copyright issues. In the archived course material mode, copyrights are obtained for the number of student in a class cohort. However, in the updated courses material mode, rights for copyrighted material will need to be obtained for the number of students across all four years. Therefore with either mode, the best practice is to obtain the permission to use copyrighted material for the number of students in all four years.

The archived course material mode does not facilitate collaboration between current and past students because of the segregation between the current and archived course content. Also because this mode is for completed courses, there is most likely very little collaboration among the students with access to these materials.

The updated course material mode facilitates collaboration between current and past students because it allows for peer teaching through moderated discussion boards and chat modules. Through these modules, current students

can ask questions of the past students about the content in the course. The moderated communications between past and current students would help to maintain the integrity of sequenced content. In this mode, past students act as peer tutors/ teachers for current students, while current students can act as peer tutors/ teachers for updated content that would be new to past students.

For ease of maintenance, continuity, and review, the Extended Updated Mode is preferred. The Extended Updated Mode fosters self-directed learning by presenting all material available and letting the student set the pace of learning. This mode could facilitate collaboration between current and past students because it allows for peer teaching through moderated discussion and chat tools. By sustaining up-to-date content students are provided with a valuable tool to maintain and grow their knowledge.

The disadvantage to the Extended Update Mode is the cost associated with supporting such a model. Faculty time, management of intellectual property, and the necessary curricular support staff work time are just a few factors that have to be weighed. Learning Management Systems may not allow for this type of content update, storage, or access by all students across all four years.

Cohort Model	Comments
Access	Students are assigned to a group/cohort within the LMS.
	Provides access to course content based on cohort.
Advantages	Allows for continued collaboration and communication among current and past students (for archived and updated course mode), allowing past students to act as peer tutors.
Disadvantages	Costs and maintenance of updating and managing content and moderating forums

II. State and Federal Regulations

In addition to considering the basic elements of an LMS (such as tools and features), groups tasked with evaluating an LMS should also be aware of state and federal regulations applicable to their institution. The section below discusses three critical regulations that affect all educational institutions nationwide. Medical schools, in particular, need to address any HIPAA related requirements when evaluating an LMS.

HIPAA

The Health Insurance Portability and Accountability Act (HIPAA) Privacy Rule[1] and Security Rule[2] require that Protected Health Information (PHI) be regarded as confidential at all times and that appropriate security measures must be applied in the use of this information. There are no restrictions on the use or disclosure of **de-identified** health information (*i.e.* after removal of specified identifiers of the individual). Permitted uses and disclosures[i] and the specific identifiers[ii] that must be protected are explained in a variety of sources and additional information on disclosures and identifiers can be found in the Endnotes section.

An LMS provides a secure environment for teaching and learning. In addition, using the LMS for clinical education creates opportunities to emphasize ethical and professional conduct with respect to patients' rights and providers' responsibilities. For medical schools, the issue of students storing PHI in an LMS is a real possibility. These concerns can be addressed through training and through the knowledge and adherence to HIPAA security and privacy rules.

Some considerations when evaluating an LMS is how the institution will address HIPAA compliance and security issues, particularly when the LMS is hosted outside the organization, such as in the Cloud. Although the posting of PHI to an LMS should be strictly prohibited, the opportunity exists for a student to share PHI while using a wiki or when submitting an assignment.

FERPA

The Family Education Rights and Privacy Act of 1974 (or FERPA) is a federal law designed to protect the privacy of a student's educational, financial, and health records. Without the appropriate student information releases, student account and academic records cannot be discussed with a parent, guardian, spouse, or other parties.[3]

Security measures should be in place to ensure students have access to their personal information through the appropriate authentication systems and that only course instructors, administrators, and administrative staff with an "educational need" are allowed to view student records on an LMS. The issue of accessibility is aided through LMS features that allow for roles-based permissions. This allows LMS administrators to give specific access to pre-defined roles, thereby minimizing the sharing of private student data.

ADA Compliance Issues

Americans with Disabilities Act (ADA) compliance is also an important consideration when evaluating an LMS. Most LMSs adhere to ADA specifications. However, systems will vary as to how they treat certain specifications.

[1] http://www.hhs.gov/ocr/privacy/hipaa/understanding/summary/index.html
[2] http://www.hhs.gov/ocr/privacy/hipaa/understanding/srsummary.html
[3] http://parent.osu.edu/resources/academic_/ferpa

If ADA compliance is of concern, then a proper evaluation should include a user group to test the systems under consideration.

Selecting an LMS that complies with ADA requirements establishes minimum standards for the accessibility of web-based information and services considered necessary to ensure compliance with applicable federal regulations.[4] Some state regulations exceed those of ADA and these should be considered when evaluating accessibility features of an LMS.

[4] http://ada.osu.edu/resources/webaccessibilitypolicy.pdf

III. Infrastructure, Security, and Technical Support

Security issues and technical support for the basic principles of access, portal functionality, and collaboration are closely related and are described collectively.

User Access and Accounts

In general, an LMS should support one point of access with a single sign-on to the LMS (to allow users to move between LMS and institutional databases without having to enter multiple usernames/passwords); and have secured user access, including some common and continually updated method of authentication and data encryption.

Linking the LMS to a central university directory via Lightweight Directory Access Protocol (LDAP) or Active Directory (AD) is a recommended approach for authenticating users. An LMS also needs to have plenty of bandwidth and storage capabilities. This system should be maintained according to the standards of campus network security while allowing for intra-campus and external access. Interoperability, cross-browser and cross-platform issues need to be considered. It should also have user tracking/trending, accountability, secure files, folders, applications, and databases.

If the LMS is linked to a central directory, such as LDAP, this raises an important issue that schools must take into consideration: Who can access the LMS? For LDAP users, visiting or clinical affiliate faculty and students may not have the necessary credentials to authenticate and access the system. LMS administrators should develop a plan to manage login authentication and access for these users. Many LMSs include user permission tools to control access to specific areas of the LMS once they have been authenticated through the LDAP server or other gateway.

Security

There should be well defined security policies and processes. Security should be role-based, with access to various components of the LMS being defined by the user role (*e.g*., permissions for admins, faculty, and assistants vs. permissions for students). The LMS should support some kind of nested security so that users within their own defined permissions can themselves enable additional security and lock particular items. Optimally, security and access would be maintained by a central group, which would be most familiar with the users of the system (*e.g*., Office of Medical Education).

An LMS should also allow for drilling down of permissions within specific user profiles. The ability to include teaching assistants (who can access assignments, but not access the grade book for example) is a necessary requirement as departments rely on support staff for clerical assistance.

Technical Support

Technical support should be provided by a central group of experts who work together to resolve issues, routinely maintain, and continue to build and enhance the LMS. Ideally this central group would have extended hours and after-hours contact numbers for emergency service. This requires robust support, beginning with strong communication between the educational and technical units. The educational unit must identify key components of the system required to support the curriculum and work with the technical unit(s) on how best to deploy those components. Technical support will be required for system maintenance, upgrades, troubleshooting, etc. One

should develop a plan for providing support to troubleshoot hardware/software problems, generate reports, administer regular data cleanup, and build/maintain utilities for the creation of course materials.

User Support

User Support should include user-training (including follow-up training, if desired) and documentation. In terms of support, the number of support staff for the LMS should vary depending on the institution's needs and size. It should also be recognized that there will be a continuum of support needs, from basic "how-to" type questions to issues of a technical nature that arise from the specific use and environment used. Institutions should take care to ensure that the widest range of support is covered in some fashion to ensure high levels of technology satisfaction. It should support all levels of the LMS and should also include in-person training, on-line educational materials—such as online tutorials or PDF/PowerPoint documents or a combination of both, and on-line chat room support. Different systems are more complex or offer more features than others, so training time will vary among institutions. Training should be offered at different times throughout the year, to ensure continuous and maximum audience potential, an up-to-date knowledge base, and troubleshooting skills and techniques.

Governance

With the administrative complexity in today's colleges and universities extending into the educational experience, the LMS for an organization has, with increasing importance and dependence, become one of those complexities. Things being asked of the people that support this type of technology may be out of their range of understanding and expertise. There are a variety of answers to these questions:

- When can we take the system down to do maintenance?
- Can we change this particular tool for a new one?
- How can we spend just enough on our help desk to provide the best service for our LMS at the hours it is needed the most?
- How shall we prioritize enhancements?

All of these require responses that are best handled by input from a variety of stakeholders.

Having a culture that understands and utilizes governance is critical to the future success of a LMS. A governance group for the LMS should be considered to help guide the strategic value of the tool. Any such governance group should be formally recognized at the college or university and also be part of the formal governance structure of that organization. Such a group should have representatives from the consumers of the LMS – the faculty, students and staff. Establishing this group and the accompanying ground rules will facilitate communication and structure with fair and deliberate direction for the LMS.

IV. LMS Review and Selection Process

Selecting a Learning Management System

While each school's specific requirements for a learning management system differ, there are key principles for selecting an appropriate LMS. A collection of experts from different schools developed this six-step framework to serve as a general guide and overview of the LMS selection process for academic IT decision makers. This framework is geared towards identifying a commercial product or vendor with a follow-up discussion about open-source solutions and their unique approach.

Prior to beginning the review and selection process, a steering committee representative of the organization's stakeholders (faculty, staff, students, etc.) should be formed. This committee would be responsible for conducting a needs assessment, prioritizing the needs, evaluating products and making the final LMS selection.

One additional consideration prior to beginning the process of engaging with vendors is to consult your institutions purchasing or finance department. Based on the organization's policies, the steering committee may need to follow additional steps outside those listed below. Moreover, organizational or state policies may impact the type of document used to solicit proposals..

Step 1: Consider Audience and Learning Environment.

As curricular needs change and grow, strategies to address teaching and learning challenges change as well. While the focus of education is teaching and learning outcomes, a school's LMS is often tied directly or indirectly to curriculum changes and innovation.

The selection committee should draft a list of key considerations and questions, including:

- Who are the instructors and what are their teaching/delivery styles and needs?
- Who are the learners and what are their needs and expectations?
- What are the teaching and learning methodologies we use or plan to implement?
- In which locations and in what situations does learning take place that will be affected by the LMS?
- What resources are currently used to help achieve successful teaching and learning?

REMEMBER: There are a variety of factors that enable a solution to work in one environment and not in others. Therefore, selecting an LMS solely based on the success it had within another school is ill-advised. Think about the individual school's culture, organizational structure, types and number of programs and other factors that need to be considered before envisioning a new LMS implementation. This task can be time consuming but is extremely valuable in achieving the desired end result.

Step 2: Determine Requirements.

Requirements should be prioritized from high to low. High-priority (or core) requirements are those absolutely necessary for the LMS to perform during its initial launch. If a core requirement cannot be met by an LMS, that system should be dropped from consideration. Medium-priority requirements must be met in the initial or subsequent phases of implementation. Low-priority requirements are "nice to have" and may be delayed indefinitely. A useful tool to begin the process of identifying a feature list is CSU Chico's Learning Management System II Strategic Review - Topics and Questions. This document provides a starting point to help define a school's LMS requirements.

The following areas of focus are recommended when determining requirements but are not meant to be exhaustive:

Registration and Enrollment: What student information system (SIS) exists and is an interface to the LMS envisioned? What data will be sent between the systems? Is it a one-way communication (SIS to LMS) or two-way (SIS ↔ LMS)?

Authoring Tools: What tools are envisioned to develop, maintain and store learning content? Issues related to authoring-tool compatibility with existing learning objects, version control and content re-use should be considered.

Content Access: How will learners access content housed in the LMS? What types of content will be delivered? Is mobile-access a requirement?

Collaboration Tools: The functionality of discussion boards, chat rooms, wikis, blogs, polling and other interactive tools should be well thought out during this phase of the selection process. Collaboration is a key element of any LMS and should include the ability of cohorts to have easy access to various LMS tools requiring a moderator, such as discussion boards and chat rooms. It should allow cohorts to engage in peer teaching and learning. Additional collaborative elements should include file sharing, message boards, teacher and instructor created groups, as well as other content and administrative tools.

Evaluation Tools: What survey instruments, quizzes, and tests are needed to collect data associated with the effectiveness of programs and the measurement of student performance? Types of available evaluations vary greatly by LMS (multiple choice, matching, write-in, document submission). Systems also vary by offering standards-based import/export, such as SCORM and AICC (discussed in p. 26), and question banking options. The level of evaluation security also varies with different LMS.

Communications and Workflow: How will students submit assignments and how will instructors collect them? Should a system keep all transactional material internal or is it acceptable for assignments to leave the system (i.e.; use of independent email accounts to send and receive submissions)?

Grading: How are grades calculated and compiled (manual or automated), reviewed and edited by faculty and shared with students? What formats are grades: letter, letter with plus/minus, numeric, pass/fail, checkmark, text for feedback, etc.?

Languages and Accessibility Accommodations: The LMS selected may need to be customizable in order to meet language needs and Section 503 considerations. ADA considerations are also important (discussed above).

Customizability: Will the out-of-the-box LMS suffice or will the school's needs potentially grow or change over time? Some LMS systems allow add-ons or tailored modules to add different functionality. Other LMS options allow for developing easy tie-ins or even embedded tools. Consider costs and support of the add-ons.

Technical Aspects: Will the LMS function as a stand-alone system or does it need to co-exist with other systems? Single sign-on capability (through LDAP, Active Directory, or other directory services) and portal functionality (such as u-Portal or through an existing portal wrapper) should to be considered.

Step 3: Develop a Request for Proposal (RFP).

With a requirements document in hand, develop a request for proposal (RFP). An RFP is used to solicit proposals from potential vendors. An RFP should include a project plan for implementing the vendor's solution based on your requirements and financial considerations/constraints. The project plan should include start and completion dates, milestones, and identify ownership for achieving each task.

It is advisable to note the priority weights of each requirement and list them in the order of priority from high to low. Be certain that every requirement is specifically worded so that vendors provide details rather than general responses. It is also helpful to provide "scenarios" in the RFP that describe situations in which the LMS will operate. This will assist vendors in giving a context to their responses.

The University of Michigan's Learning Information System Request for Information is an example of a detailed request for proposal.

Step 4: Conduct Vendor Presentations and Review Systems.

After submitted proposals are reviewed, meetings and demos should be scheduled so vendors can address specific questions and demonstrate their proposed solutions. If scenarios were provided in the RFP, vendors should be required to demonstrate them. It is also important for vendors to clarify what part of the functionality is included out-of-box and which customizations are beyond the quoted price.

The goal of the review should be to determine if the LMS meets the highest-priority requirements. If a core requirement cannot be met by the LMS, that LMS should be placed at the end of a rank list, or should be given lesser consideration. Analysis of the committee's ratings should lead to a short list of vendors. During your systems reviews, it is highly recommended that you consult with peer institutions and organizations such as AAMC's Group in Information Resources for recommendations and feedback. Many groups and universities have been through this process and have published or are willing to share comparison charts and reviews of each system. Refer to the references at the end of this guide for more information.

Step 5: Research Companies.

Research the vendors whose products are in consideration. Although company information is usually available on each vendor's website, non-biased information should be sought. One e-learning firm, Brandon Hall Research, offers extensive resources on LMS products and vendors for a fee.

Consider the following when determining the company or provider with which you plan to partner:

- **Financial Stability:** When possible, evaluate a company's financial status to ensure that it will remain a viable player in the market before making your final selection.
- **Client Relations:** Talking with references can be critical in understanding how responsive a vendor actually is. Prepare a questionnaire to evaluate critical areas that strike your organization's comfort zone.
- **End-User Support:** Ask vendors for their service level agreement (SLA) and pay particular attention to the defined roles, responsibilities, and response times associated with various types of incidents. Will the school provide the first tier of support to students or faculty, relying on the LMS vendor as support only to the local support people? Or do all students and faculty members need access to the LMS end-user support team?

- **Pricing:** When considering pricing, reflect on your functional and technical specifications. What would be the cost if the selected vendor didn't conform to the committee's expectations?

Step 6: Make the Selection.

The final step of the process, after the committee's careful review and discussion, is to select an LMS. This is a serious and long-term investment, so it is important to have complete cooperation among the members of committee. It is also advisable to consider a contingency plan in case unexpected delays or problems arise during the purchasing or implementation process.

Summary

While every school's requirements for a learning management system differ, most schools follow a similar process for selecting a LMS. The process outlined above has proven successful for the collaborating authors and offers a good starting point for other universities and a way to keep an objective eye based on overall goals. A committee's careful analysis of the learning environment and requirements, a clear RFP, and solid research into systems and vendors should yield a successful implementation.

V. Integrating an LMS into a Medical Education Portal

A portal is "a site serving as a guide or point of entry to the World Wide Web and usually includes a search engine or a collection of links to other sites arranged by topic".[5]

Ideally, an LMS system should have the ability to function as part of a portal for accessing and inputting a variety of information by a diverse user population, including students, faculty, and administrators. Such a system should avoid redundancy by sharing faculty and user data among systems, including scheduling, registration, on-line assessments and grade books, and course calendars. An LMS/portal should also provide enough flexibility to meet the discrete requirements of the various stages of medical education (UME, GME, and CME). It should include the ability to view and edit multiple content formats and provide access to discussion threads and online learning tools.

The LMS/portal should track clerkship patient encounters, learning objectives across the curriculum, and usage of resources (i.e. most accessed/used resources). Students and faculty should be able to collaborate and/or build learning material. Educational/clinical responsibilities should be listed prominently. A global search function should be available.

As an example, Wake Forest University School of Medicine has integrated their LMS on SharePoint with its education portal (eWake), which allows students and faculty to access resources from a single gateway. The tools used to build the portal are Microsoft SQL and .NET framework. Microsoft SharePoint has also been used for many elements of the portal. For example, each clerkship has its own SharePoint site that houses course materials, course objectives, schedules, evaluations, assignments, discussion boards, contacts, etc. SharePoint is also used as a miscellaneous bulletin board for the students. The students use this area to hold documents, post pictures, host discussions, and conduct surveys.

The eWake portal at Wake Forest University School of Medicine is used as an entry to all curriculum materials and links that medical students need throughout their education. The central item is the calendar that displays the individual student's educational schedule. Drilling down into this calendar per event allows the student to gain access to course materials uploaded by the teaching faculty or administrative staff.

In addition to this calendar, students can also add links to internal resource sites such as electronic journals, databases and textbooks; various electronic teaching applications such as the Human Anatomy Atlas, Hyperbrain, and Virtual Microscopy; financial aid; student services; a student directory; and the Medical Center electronic medical record. There is also a section to hold links to any favorite external URL that the student may use frequently. The portal also has sections where policies, reference materials, and small group cases are accessible. The SharePoint bulletin board is also accessible from the eWake portal.

Teaching faculty use the portal to gain access to all of their teaching materials. They are able to use utilities to upload, delete, and maintain their materials as well as to add course objectives and link them to USMLE standards. All of their teaching activities are listed for their review. The administrative staff use the portal to assign small group facilitators, make announcements to students, assign and release evaluations, and track evaluation completions among other things.

The portal also has a search function that will search across the curriculum by lecture titles, objectives, and/or files. This search capability has the intelligence to only allow searching of materials for which the student currently has access. For instance, the search by a first year medical student would not search curriculum in any other year of medical school that has not yet been released to this student.

[5] http://www.merriam-webster.com/dictionary/portal

The AAMC is developing new resources "that will serve to streamline and optimize the use of medical education data, informing education research ad supporting continuous improvements in academic program effectiveness."[6] One of these tools is the **Curriculum Inventory.** This tool will serve as a central repository for curriculum data from curriculum management systems of which the LMS is a part. Detailed curriculum data will be gathered from a school's LMS and perhaps other sources at the school to populate and XML file utilizing the MedBiquitous XML Curriculum Inventory standard which will then be uploaded to the AAMC.

In summary we recommend that the LMS be integrated with the education portal in order to make fullest use of both technologies. Ideally, the LMS should include the continuum of medical education (i.e., Undergraduate Medical Education, Graduate Medical Education and Continuing Medical Education) and integrate inter-professional education whenever possible. The basic information in the LMS can be shared externally (i.e., with other schools) via the Curriculum Inventory (a free service from the AAMC starting in fall 2013). This will allow medical schools to collaborate with each other. With proper support and strategy a LMS can be successfully integrated with the education portal at any school.

[6] https://www.aamc.org/initiatives/medaps/about/

VI. Open Source Solutions and Operating Options

Commercial learning management systems such as Blackboard and Desire 2 Learn, are well known to educators. However, the rising cost of proprietary LMSs has spawned a market for open-source alternatives such as Sakai (http://www.sakaiproject.org) and Moodle (https://moodle.org/).

Open source/community-source software is usually free to install, but comes at the expense of higher support since no business is in charge of the system. In general, the costs associated with implementing open source/community source software are generated through the technical and personnel resources that a school must put towards customizing, implementing, and supporting the solution.

Do It Yourself (DIY)

Open source LMSs are available in one of two ways. The most common is the do-it-yourself installation in which the school patches the system, installs the application, performs upgrades, and monitors its performance. It will also be necessary to interface the LMS with the school's SIS and determine a user authentication model consistent with the school's security policies and IT systems. The decision to be entirely responsible for the installation, operation, and maintenance of an LMS requires technically competent staff who will be dedicated to the project.

Vendor-Supported Open Source Solutions

Moodle and Sakai, the two most popular open source LMSs, are also available as vendor supported services. For an annual fee based on the number of active accounts in the system, a school can offload the installation, operation, and maintenance of the entire LMS to an application service provider. Services also include licensing (if applicable), student information system integration, system customization, and providing technical support to key personnel at the school. Technical support does not usually cover direct student and instructor support. In situations where a school does not have the technology infrastructure or staff necessary to support an always-on system, the service model may be cost effective. The downside to the service model is that system customizations and overall control can become difficult.

VII. Leveraging LMS Data

Curricular development in medical education is a uniquely collaborative process. Students acquire competencies over years with hundreds of instructors providing lectures and clinical experiences, assessment, and feedback in multiple settings. Effectively designing those experiences requires, at a minimum, awareness by instructors of the entire curriculum and their role with in it.

An ideal LMS would support the collaborative development of curricular goals, assessment methods, and instructional methods. Further, it would facilitate the acquisition and tagging learning elements like images, videos, rating scales, and the development of instructional and assessment methods like presentations, cases, online modules, OSCEs and MCQ tests.

When evaluating LMSs, consider how it handles and/or manages content. Is there a central repository that allows faculty the flexibility to develop and share content among the various strands? Or, are courses housed in individual "shells" with no communication with other courses?

Once instructional methods are developed, the ideal system would provide access to students for just in time learning and for peer review including feedback. Finally, it would track when the content should be reviewed to ensure it continues to be current.

LMSs can be also used to advance the study of effective teaching methods. Medical Education Research (MER), also known as the Scholarship of Teaching and Learning (SoTL), suffers from a lack of resources[7]. Faculty members do not have the time, funding, or expertise to engage in SoTL, so efforts to research the efficacy of educational technology solutions are limited.

SoTL efforts suffer from lack of collaboration and small sample sizes. Frequently studies focus on comparisons of technology enhanced teaching and more traditional face to face methods[8] . By leveraging the tools in an LMS, instructors are able evaluate the effects of teaching with different types of online strategies as well as the use of formative and summative quizzes. For example, students can be randomly assigned to groups and consented to participate in a study within the LMS. Using the selective release tools in the LMS allows study participants students were able to see the pieces of the curriculum randomly assigned to them.

[7] Gruppen, L.D. (2007). Improving medical education research. *Teaching and Learning in Medicine: An International Journal, 19*(4).
[8] Cook, D.A. (2005). The research we are still not doing: An agenda for the study of computer-based learning. *Academic Medicine, 80*(6), pp. 541-548.

VII. Future of the LMS

It is reasonable to ask if the current LMS software will be able to meet the future needs of our learners. Does the traditional LMS reflect how the world currently works? How will Massive Open Online Courses (MOOCs) and social media change the LMS? The traditional model of a commercial vendor or major open source LMS providing all features from a single source will probably be supplanted over the next 5-10 years by instructor- or institution-directed creation of courses using Web2.0 products such as Google Course Builder for the frame and assessments with social media tools serving as the interactivity components. Further, the movement to MOOCs means that it will be necessary to automate large portions of traditional LMS functions.

LMS Cloud Computing and Web 2.0

Cloud computing is a model that allows convenient access to resources such as networks and servers on demand with minimal effort for releases and provisions. The National Institute of Standards and Technology (NIST) defines cloud computing as having five characteristics: on demand self-service; broad network access; resource pooling; rapid elasticity or expansion; and measured service[9]. These characteristics allow millions of people the ability to globally access information from any device that connects to the internet and has dramatically changed the way people communicate and collaborate.

These technological advances have forced LMS software to converge with social networking and collaboration tools. LMS vendors are trying to incorporate some of these characteristics into their software while many institutions are trying to have a flexible scaffold of tools such as WordPress and Google Apps. Desire2Learn, for example, released an update to its LMS that incorporated social networking tools such as Google+ and Facebook, [10] while Blackboard has incorporated course-specific discussion rooms and wikis to facilitate collaborative work among users.

Dr. Gary Brown, the director of the Center of Online Learning at Portland State University, uses the metaphor of a fast comet to describe the shift toward 21st century education that is focused on collaboration, projects, student-centered learning, and informal learning. He warns that "there is a comet heading toward planet education, and it is coming very, very fast and the Web 2.0 and cloud-based technologies are the fuel that is powering the comet". [11] Some educators, such as John Mitchell, Vice Provost for Online Learning at Stanford University, predict that with the increased ease of deploying such technology that within five years, interactive video, social networking, and even laboratory-simulation course components "will be as prevalent on campus as, say, PowerPoint slides are now."[12]

Another shift in pedagogy driving changes in the LMS market is the growth of MOOCs. MOOCs will impact the LMS legacy by requiring technology that transforms the boundaries of the traditional LMS. The two key features of a MOOC are open access and scalability. Open access allows participants to access a course without paying a fee or being enrolled at any institution. Scalability allows the course to support an indefinite number of participants. This has necessitated changes in traditional views of authentication, course management, and infrastructure to support such large numbers of users.

Stanford, for example**,** offered three courses**,** and 450,000 people expressed interest. Coursera, a "course management" system designed for MOOCs, which launched in April, 2012 had more than 100,000 participants in

[9] http://csrc.nist.gov/publications/nistpubs/800-145/SP800-145.pdf
[10] http://www.umassonline.net/news/2895.html
[11] http://campustechnology.com/articles/2012/03/29/rebuilding-the-lms-for-the-21st-century.aspx
[12] http://chronicle.com/article/Whats-Next-in-Online/134230/

its first courses.[13] As of August 16, 2012**,** more than 1,080,000 students from 196 countries had enrolled in at least one course offered through Coursera.[14] To effectively manage this large number of participants, Coursera has developed artificial intelligence-based tools for routine processes such as administering and grading of assessments.[14] The incorporation of automated, intelligent processes will be necessary for LMSs that cater to MOOCs.

Coursera and edX, a joint initiative of MIT and Harvard, are currently non-profit. However, Coursera is exploring mechanisms for producing a profit through certifications, similar to the process currently used by Udacity. Udacity, is a for-profit online education venture started by Sebastian Thrun of Google and Peter Norvig of Stanford.[15]

In September 2012, Google launched the open source "Google Course Builder".[16] This project allows users that have some skills with HTML and JavaScript to make their own learning resources, complete with scheduled activities and lessons. It packages the software and technology that was used to build Power Searching with Google online courses. This will allow faculty and institutions to not only create their courses but also to manage the platform.

Web 2.0

The fundamental characteristic of Web 2.0 technologies is the collaboration of members for the development of user-generated content. Social media sites, such as Facebook and Twitter are Web 2.0 technologies. A static website is not considered a Web 2.0 technology. As discussed above, more LMS companies are incorporating social media sites and Web 2.0 technologies into their systems. How they are incorporating Web 2.0 technology varies.

SCORM and e-Learning

Sharable Content Object Reference Model (SCORM) is a project of the Advanced Distributed Learning (ADL) Initiative, which comes out of the Office of the United States Secretary of Defense, and is collection of standards and specifications for web-based e-learning. [17] To say that an LMS is SCORM compliant means that it can host and display a SCORM object. The degree to which a SCORM object operates and user data is recorded varies across LMSs.

SCORM is the most commonly used e-learning standard. An LMS that is SCORM compatible can host any SCORM compliant product. The greatest benefit of this is that applications developed using SCORM compliant software are LMS agnostic, making it easy for developers to create and host content in a variety of platforms.

With the update to SCORM 2004, sequencing was introduced. This allowed users the ability to "bookmark" their location within a module or be forced to follow predetermined training/learning path.[18]

Another useful feature is that SCORM provides the ability to create content outside an LMS and import it for use, tracking, and grading of student performance. As long as the content is developed using SCORM complaint software, the package will function as though it were native to the LMS. One might use SCORM compliant

[13] http://www.fastcompany.com/3001420/columbia-brown-and-15-more-universities-join-courseras-free-online-platform
[14] http://blog.coursera.org/post/29062736760/coursera-hits-1-million-students-across-196-countries
[15] https://www.udacity.com
[16] http://techcrunch.com/2012/09/11/google-launches-open-course-builder/
[17] http://www.educause.edu/initiatives/policy-and-security/educause-policy/resources/georgia-state-copyright-case-resources
[18] http://en.wikipedia.org/wiki/Sharable_Content_Object_Reference_Model

software to develop interactive quizzes that allow for video and audio and that is more robust that an LMS provides. Once packaged and uploaded, students can complete the quiz and their scores will be recorded in the grade book.

SCORM is also used to develop e-learning modules as there are a variety of solutions currently available that facilitate the development of interactive lessons without the need for programming knowledge or software development experience. Products such as Captivate, Storyline, and Quizmaker allow content developers and faculty to develop supplemental learning materials, package them to SCORM, publish them to an LMS, and track student performance. Since the learning modules are developed outside of the LMS, changing systems does not affect the module. Moving SCORM objects to a new LMS requires minimal labor on the administration side.

The most current version of SCORM is SCORM 2004. When researching an LMS, verify which version of SCORM and what other standards, if any, they support. An alternative to SCORM is the Aviation Industry Computer-Based Training Committee (AICC) standard. This standard provides for nine Guidelines and Recommendations (AGR's).[19] Seven of the nine AGRs have no formal tests to provide compliance. Therefore, LMSs can claim AICC Compliance if they comply with any one of the nine AGRs. Organizations that rely on AICC courseware should discuss with potential vendors precisely with which AGR they comply and to what degree.

Another consideration is the degree to which the LMS will report on data collected using SCORM and/or AICC compliant software. The ability to run item analysis and statistical reports is possible as the data collected with SCORM compliant software allows for this type of analysis. However, the LMS would have to allow for the access and reporting of this type of data.

Tin Can API

Tin Can API is a new specification for learning technology that has a greater ability to collect user data than SCORM. The Tin Can API expands data capturing to multiple learning environments, such as mobile learning, offline learning, and social learning.[20] This API also collects more user data than does SCORM, such as detailed test results and the ability to collect multiple scores. As this is a new technology, most LMS systems do not support it. However, more and more are incorporating Tin Can API compatibility into their platforms.

LMS Copyright and Fair Use

In May 2012, a landmark decision about academic fair use was announced related to a lawsuit brought by academic publishers against Georgia State University[21]. Of note, the judge wrote "There is no reason to believe that allowing unpaid, nonprofit academic use of small excerpts in controlled circumstances would diminish creation of academic works." EDUCAUSE[22] a nonprofit association, whose mission is to advance higher education through the use of information technology, has a policy document that includes resources describing the decision and its impact.[23]
The decision included a definition of fair use with the following factors being considered:

1. Purpose and character of use: teaching and scholarship in a nonprofit educational institution favors fair use

[19] http://www.aicc.org/joomla/dev/index.php?option=com_content&view=article&id=63&Itemid=21
[20] http://tincanapi.com/overview/
[21] http://www.educause.edu/initiatives/policy-and-security/educause-policy/resources/georgia-state-copyright-case-resources
[22] http://www.educause.edu/
[23] http://net.educause.edu/ir/library/pdf/EPO1204.pdf

2. Nature of the copyrighted work: non-fiction and academic favors fair use
3. Amount and substantiality of the portion used: either 10% of a work with up to 9 chapters or 1 chapter in a work of at least 10 chapters included in fair use
4. Effect of the use on the potential market: if there was "no evidence in the record to show that digital excerpts from this book were available for licensing" then fair use was favored. The Copyright Clearance Center, in addition to the publishers, has a potential market that could be impacted.

The decision provides better guidelines for undergraduate campuses; however, the publishers of medical and scientific journals were not directly involved. As with HIPAA privacy and security, the copyright issues that arise with the LMS provide another opportunity for educators to stress the importance of ethical and professional behaviors.

VIII. Clerkship Management Systems

Although clerkship management systems are distinct systems from an LMS, it is an important consideration for schools researching LMS systems. Clerkship management systems track patient encounters, collect preceptor and student evaluations, and track student completion of core cases.

LMSs are not designed to meet the needs of the clerkship years due to the specific requirements of the clerkship experience and the fundamental differences of the way the curriculum is delivered. As a result, schools will typically use an LMS for the pre-clinical years and a clerkship management system for the clinical years. This setup results in student, educator, and site data being stored in two distinct databases making it difficult to report on student performance across the four year curriculum. However, tracking and reporting on an individual student performance longitudinally is an emerging trend in medical education.

Student evaluations, such as narrative evaluations, formative, or non-cognitive evaluations (*e.g.*, those evaluations that track student behavior and/or professionalism) are important for student promotion and identification of struggling students. Unfortunately, by using two systems (one for pre-clinical and one for clinical) medical schools are faced with an inability to generate reports across the curriculum.

An important consideration for any system being evaluated by a medical school must be the ability of the solution to integrate and allow access to its data repository for reporting purposes. Some systems do not allow for this type of access and would affect your ability to view a comprehensive student profile. If not, then the medical school should consider either developing an in-house database that can access and report on the data in the systems or purchase a data aggregation solution.

IX. Conclusions

With the widespread use of LMSs, institutions need to continually examine the potential of these systems for more innovative and collaborative uses. Top considerations for any future LMS include such technological issues as security, support, and availability of the product (i.e., limited downtime). Ideally it should be able to support the next generation of e-learning tools and be intuitive, customizable, interactive, easy to use, integrate with other applications, fast, efficient and mobile. LMSs should be learner-centric as opposed to course-centric and should support self-regulated learning that is outcomes- and competency-based instead of time-based. Web-based materials represent another component, and those materials should conform to e-learning standards.

As considerable innovations continue in LMS implementation, it is advantageous for institutions to come together nationally to define and expand best practices to guide universities in implementing future LMS features. To devise an ideal LMS, current systems should be thoroughly assessed for their relative strengths and weaknesses, and further research should be done on the varying potentials of commercial, custom and open source LMSs. Current systems and system types (open source, commercial, etc.) should be scrutinized for content and comparatively evaluated to determine whether there is a clear front-runner in terms of service. Not all commercial packages can handle each organization's needs, so the system should be *easily* customizable and integrate with other educational systems.

In addition to best practices, cooperating institutions should agree on common technical, legal, quality assurance and interoperability standards. Technology standards and specifications for healthcare education should allow for the exchange of learning components (e.g., online content and training modules, quizzes), data (for aggregate analysis), and software components. Example standards could include IMS (e.g., Learning Design and Content Package), and IEEE (Learning Objects Metadata, MeSH or SCORM for metadata). As features for LMS packages evolve, institutions should also ensure that the standards of interchange evolve to keep pace with new technologies. A focus on standards of interchange, coordination, interaction and interoperability will allow for enhanced inter-school collaboration while allowing for LMS implementation independence between collaborating schools as seamless as possible.

A key point of discussion is the notion of finding one system that has all desired features or having a system that is built in a modular fashion wherein institutions can build their own modules with preferred features from the common stock. As mentioned in the guide, there is not one system that currently includes all of the desired features, especially with regards to collaboration. Institutions will need to have flexibility to choose individual tools based on their needs. It may be worthwhile to approach the problem from the perspective of being able to connect these different tools in a way that allows for constant change and adaptation while still maintaining a cohesive user experience. By taking the approach of having a web-based system it becomes possible to use API architecture in these tools to make use of their capabilities without sacrificing the user experience.

Another important consideration involves the financial and manpower resources to support this initiative. Will there be a specific budget, and who will create it? Staffing issues, particularly related to technical support, remain a concern as well. Other challenges exist including cost, reliability. The value of continuing this discussion and working on common standards and guidelines for LMS that meets institutions current and future needs is of utmost value to students and faculty alike.

The intent of this paper was to describe this diverse group’s discussion and thoughts on this important subject.

X. General Recommendations

Initial Stages of LMS Selection
Before selecting the steering committee, discuss with your organization's purchasing or finance department on the appropriate legal requirements prior to engaging with vendors. Certain state or intuition policies may dictate the precise steps for this process.

Feature Requirements
Reviewing the requirements for an LMS based on a variety of users is a critical step in the LMS evaluation and selection process. Ensuring that staff, students, and faculty have a voice in the review and selection process will aid in the deployment and implementation of the chosen system. Take ample time to identify and prioritize needs and functionality for all user types.

Security Measures
Linking the LMS to a central university directory via Lightweight Directory Access Protocol (LDAP) or Active Directory (AD) is a recommended approach for authenticating users.

Developing policies to determine roles-based access to the LMS must address FERPA concerns. Policies should also address HIPAA compliance and the prevention of HIPAA violations by students or faculty by posting and/or uploading personal health information (PHI) to the LMS.

Technical Support
Some LMSs provide a technical support line for student issues; availability depends on the support agreement purchased by the school.

Portal Integration
It is strongly recommended that an LMS be integrated with an education portal in order to make fullest use of both technologies. The LMS should include the continuum of medical education (i.e., UME, GME, and CME). Basic information in the LMS can be shared externally (i.e., with other schools). Doing so will allow medical schools to collaborate with each other. With proper support and strategy, an LMS can be successfully integrated with the education portal at any school.

Integration with a student information system (SIS) is also important to the development of a comprehensive student and data management system.

Research Other Medical Schools
Throughout this process, it is recommended that you contact other medical schools that have gone through this process. Most schools will gladly share their lessons learned. It is also recommended to reach out to schools using those vendors on your short list to gauge how well the systems are working to meet their needs and support technical issues after the implementation process.

XI. Resources and References

Brandon Hall's LMS KnowledgeBase 2008
http://www.brandon-hall.com/publications
A source of detailed LMS information is the LMS KnowledgeBase 2008, an online service of Brandon Hall Research, an independent e-learning consulting firm. The comprehensive database stores in-depth profiles on over 70 learning management systems and provides detailed company profiles.

California State University-Chico, Learning Management Systems II Strategic Review
http://www.csuchico.edu/tlp/LMS2/LMS%20II%20All_Questions.pdf
CSU Chico's document provides a highly detailed and structured list of questions that can be useful in considering the functional requirements of a LMS.

EduTools
http://www.edutools.info/static.jsp?pj=4&page=HOME
The EduTools website, a community-driven project of the WCET–Western Cooperative for Educational Telecommunications—was built to assist higher education institutions in their decision making process in evaluating and selecting learning management systems. The website reviews each product by researching and describing more than 40 product features and allows visitors to perform product comparisons, search and list features and use a "summative decision tool" in making a selection decision.

Learning Information System Request for Information
http://sitemaker.umich.edu/enablingtech/files/20070227lms_rfi_medschool.pdf
The University of Michigan's *Learning Information System Request for Information* is an example of a detailed request for proposal specific to a medical school's needs.

The Medbiquitous Curriculum Inventory Standard
http://medbiquitous.org/curriculum_inventory

Top 10 LMS Purchasing Mistakes (and How to Avoid Them) *by Dave Egan, THINQ Learning Solutions*
http://www.coxec.com/Top_10_LMS_Mistakes.htm
Though a bit dated and leaning toward corporate adopters of LMSs, Egan's article raises critical issues important for any LMS purchaser to consider.

XII. Endnotes

[i] Include (5) Public Interest and Benefit Activities; and (6) Limited Data Set for the purposes of research, public health or health care operations. Covered entities may rely on professional ethics and best judgments in deciding which of these permissive uses and disclosures to make.

[ii] (A) Names; (B) All geographic subdivisions smaller than a State, including street address, city, county, precinct, zip code, and their equivalent geocodes, except for the initial three digits of a zip code if, according to the current publicly available data from the Bureau of Census (1) the geographic units formed by combining all zip codes with the same three initial digits contains more than 20,000 people; and (2) the initial three digits of a zip code for all such geographic units containing 20,000 or fewer people is changed to 000; (C) All elements of dates (except year) for dates directly related to the individual, including birth date, admission date, discharge date, date of death; and all ages over 89 and all elements of dates (including year) indicative of such age, except that such ages and elements may be aggregated into a single category of age 90 or older; (D) Telephone numbers; (E) Fax numbers; (F) Electronic mail addresses: (G) Social security numbers; (H) Medical record numbers; (I) Health plan beneficiary numbers; (J) Account numbers; (K) Certificate/license numbers; (L) Vehicle identifiers and serial numbers, including license plate numbers; (M) Device identifiers and serial numbers; (N) Web Universal Resource Locators (URLs); (O) Internet Protocol (IP) address numbers; (P) Biometric identifiers, including finger and voice prints; (Q) Full face photographic images and any comparable images; and ® any other unique identifying number, characteristic, or code, except as permitted for re-identification purposes provided certain conditions are met. In addition to the removal of the above-stated identifiers, the covered entity may not have actual knowledge that the remaining information could be used alone or in combination with any other information to identify an individual who is subject of the information.