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An Evidence-Based Approach for Deeper Understanding of Student, Teacher, and Learning Dynamics

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An Evidence-Based Approach for Deeper Understanding of Student, Teacher, and Learning Dynamics

Abstract. Learning Management System (LMS) technology, and a Customer Relationship Management (CRM) perspective, can deepen understanding of the dynamics between students, teachers, and their learning environment. In addition to content delivery, LMS technology can capture data about students while they are taking classes. This capability provides a way to gather data on factors impacting student learning so they can be analyzed scientifically. Learning Management Systems are widely used in a variety of learning settings – high school, college, and workplace – and can be adapted to introduce a CRM perspective into the classroom.

Broad adoption of LMS and CRM technology requires a paradigm shift towards a student-centric model of education – and vice versa. This paper offers theoretical and practical suggestions to get started with this shift in mindset: i) using Activity Theory to create a descriptive framework to anchor and highlight interrelationships between students, teachers, and their learning environment; ii) managing the LMS-CRM system development process; iii) implementing a CRM perspective with LMS technology; iv) generating LMS and CRM-collected course statistics to support Instructional Design frameworks, such as ADDIE (Analysis, Design, Development, Implementation, and Evaluation) and others; and v) challenges and limitations using LMS and CRM technology.

Index Terms—Educational Customer Relationship Management (CRM), Learning Management System (LMS), Educational Analytics, Educational Activity Modeling, Evidence-Based Instructional Design

Introduction

A recent headline blasted on the news – "NYU professor fired after students said class was too hard urges 'tough love' from college, end to 'coddling'" – is reminiscent of the quote from the movie Cool Hand Luke: "What we've got here is failure to communicate [1], [2]." The lurid headline reflects ongoing debate in STEM classrooms on what credence should be given to teacher and student expectations and how to reconcile them when they are at odds. Ubiquitous student surveys lack scientific rigor and provide limited insight on teaching effectiveness and how to improve student outcomes. A teacher may have happy, inspired students and angry, frustrated students in the same classroom. We seek to understand why this is so and what would have helped the struggling teacher and students. Students need help learning difficult subject matter. Teachers need help understanding their students' needs and guidance on best practices. Pointing blame at each other's respective shortcomings undermines trust and learning.

Regardless of the learning setting – high school, college, university, or workplace – teachers are likely to encounter a mix of interested, disinterested, prepared, and unprepared students. Some students take subjects they do not like because they need them for graduation or to meet specific degree requirements. Some students take training classes as a condition of employment. For example, companies that do business with the United States Department of Defense (DoD) are contractually obligated to adhere to strict cybersecurity standards defined by the National

Institute of Standards and Technology (NIST). The NIST standards require DoD contractors to give their employees cybersecurity training, regardless of the company size or business type. A small three-person company with DoD contracts to sew clothing must adhere to the same cybersecurity standards that apply to a much larger company making sophisticated weapon systems. The contractor's employees may not have a degree or experience with computers, and they may resent being forced to learn cybersecurity concepts and security procedures. Company owners may resent the expense of mandatory cybersecurity training and the downtime when their employees take the training. Sometimes teachers are welcomed with open arms, and sometimes they are hardly welcomed at all. Regardless of circumstances, a good teacher endeavors to do their best to impart knowledge to their students and to help them succeed; however, there are times when both students and teachers benefit from additional support.

This is where Customer Relationship Management can be helpful. Customer Relationship Management can be implemented in many ways. It involves configuring an organization's information technology (IT) infrastructure around customer touchpoints. A touchpoint occurs whenever a customer has some form of interaction with the organization. To the extent practical, data should be collected at each and every touchpoint on the rationale and nature of the interaction and the customer's perception of the interaction's outcome. Touchpoint data provides valuable insights on customer needs and motivations and may suggest ways to increase consumption of the organization's products and services. Touchpoint data are used to: personalize recommendations and offers so they are more appealing to the customer; identify customer problems so they can be addressed proactively; and anticipate customers who are at risk of taking their business elsewhere so targeted interventions can be employed to keep them on-board. Over time, touchpoint data can be used to improve customer experiences, loyalty, and profitability [3]. Customer Relationship Management is an integral part of the business success of many companies (e.g., Accenture, Amazon, Apple, Google, IBM, Microsoft). Customer Relationship Management is widely used to conduct rigorous scientific studies on the effectiveness of marketing appeals and impacts on customer buying behaviors [3].

When reference is made to an "educational CRM system," the terminology can be misleading. These systems are typically designed to help the educational institution, not students, by supporting:
- **Inputs:** System access points for user-entered and imported data.
- **Processing:**
    - Data analysis;
    - Event information and coordination;
    - Fundraising activities;
    - Recruiting functions.
- **Data Collection:**
    - Contact information (applicants, students, alumni, faculty, administrators, staff);
    - Enrollment and admissions information;
    - Student information (personally identifiable information (PII), grades, attendance).
- **Outputs**:
    - Automated communication (email, text messaging, phone messaging, system alerts);
    - Data export (spreadsheet generation, database updates);
    - Report generation.

A key ingredient missing from the above is the notion of incentives. In a traditional business-oriented CRM system, data are collected on what, how, how much, and where the customer buys. The data are used to derive business rules to predict the customer's revenue potential and value to the company, and to identify strategic touchpoints to present incentives. Data are collected on incentives the customer accepts and declines. Each special offer is conducted as a scientific experiment designed to learn what is most attractive to a particular customer and what is the most cost-effective marketing incentive for the company to offer to them. One customer might prefer a free meal voucher while another might prefer a price discount. The CRM system helps calculate a value proposition that appeals to each customer while optimizing loyalty and profitability to the company. Similarly, it is the authors' view that educational CRM should provide tangible, meaningful benefits to students in return for their loyalty and engagement [4]. Educational CRM offers a vehicle to offer personalized incentives and recommendations that are appealing and useful to the students. It can help identify problems students are having so they can be addressed proactively, and it can be used to predict students who are at risk of dropping out so targeted interventions can be initiated to help them stay in school.

According to the Department of Education Office of Educational Technology, the priorities of k-12 schools are focused on basics: improved Internet connectivity, student access to better learning devices, development of high-quality digital learning content, and creation of Responsible Use Policies (RUPs) [5]. Ninety-nine percent (99%) of United States schools have fiber connectivity; however, only percent (38%) of all school districts meet the FCC's 1 Mbps per student standard for broadband connectivity [6]. Reliable access to electricity, computers, and a high-speed Internet connection are essential prerequisites for an operational LMS-CRM capability; however, these are not available in many schools, especially in antiquated school buildings [7], [8]. Large-scale implementation of LMS-CRM systems will not be feasible until the basics are in place in most schools. Schools must also have a champion in their ranks to promote adoption of LMS-CRM technology and teachers who are willing to learn it and use it in their classes. The authors have had success implementing LMS-CRM capabilities in k-12 settings when all these requirements are met.

Institutions of higher education (HEIs) use "CRM software to improve their recruitment programs, improve communication (with students, parents, donors and the general public) and improve fundraising efforts by strengthening relationships with alumni [9]." This use does not directly align with goals put forth by the Department of Education Office of Educational Technology, which recommends that technology should be used to [10], [11]:

- Help teachers provide targeted interventions and tailored feedback based on learner data.
- Evaluate efficacy of new teaching practices and technologies based on student outcomes.
- Provide personalized, active learning experiences to all students.
- Build research-supported teaching practices and foster professional development.
- Improve measurement of student learning against clearly mapped competencies.
- Initiate small pilot technology rollouts instead of poorly planned, large-scale rollouts that fail.
- Develop Information Technology systems in accordance with NIST cybersecurity standards.

Broad adoption of LMS and CRM technology requires a paradigm shift towards a student-centric model of education – and vice versa. The sections that follow describe how to get started with this shift in mindset: i) using Activity Theory to create a descriptive framework to anchor and

highlight interrelationships between students, teachers, and their learning environment; ii) managing the LMS and CRM system development process; iii) implementing a CRM perspective with LMS technology; iv) generating LMS and CRM-collected course statistics to support Instructional Design frameworks, such as ADDIE (Analysis, Design, Development, Implementation, and Evaluation) and others; and v) challenges and limitations using LMS and CRM technology.

Using Activity Theory to Model the Learning Environment

Activity Theory was originally developed in the 1920s and 1930s by Russian psychologists as a descriptive framework to capture the dynamics and relationships between an individual and their environment. Over the years, other researchers have extended and applied Activity Theory across many domains, including education, psychology, sociology, and computer design [12], [13], [14], [15]. Activity Theory posits that the meaning and purpose of human activity is influenced by a vast network of interconnected cultural, historical, and social relationships. People are active agents within their environment who both shape and are shaped by the tools, rules, and values under which they operate [12], [13].

Activity Theory can capture a dynamic vision of reality – like a movie that changes from frame to frame as new environmental influences manifest over time. Activity Theory is a versatile tool to visualize systems at macro- and micro-levels of detail. It can provide a high-level view of existing and possible future learning environments. It can also depict learning dynamics at the classroom-level. For example, Activity Theory frameworks have been used to study learning progress during small activity units, and in mobile computer-supported collaborative learning systems [16], [17]. Zurita and Nussbaum's research with children found that implementing an Activity Theory framework, in conjunction with Instructional Design approaches, helped improve students' technological appropriation, collaboration performance, motivation, attendance, group work skills, and communication skills [16].

Activity Theory uses a formalized network diagraming convention to model environmental settings [13]. The network diagram consists of a Subject, Mediating Artifacts, Object, and Outcome. The Subject uses external (LMS, computer devices) and internal (plans, strategies) tools to complete an Object (milestone) thereby achieving a desired Outcome. The tools, also known as Mediating Artifacts, are imbued with cultural, historical, and social significance. Mediating Artifacts influence the behavior of the Subject using them, and in turn, the larger social environment the Subject inhabits. A simple example is shown in Fig. 1. A Subject (Student) is tasked with writing a report on "Activity Theory" (Outcome). The *Student* (Subject) uses ChatGPT, Wikipedia, and Google (Mediating Artifacts) to conduct research so he can understand the concepts behind "Activity Theory" (Object). This, in turn, allows him to write a report for his class which gets an "A" grade (Outcome).

Network components can be combined to create more complex system models. In Fig. 2, a *Student* uses several Mediating Artifacts to achieve the desired outcome, which in this case is increased knowledge and a degree which provides proof of his mastery of STEM subject matter. The Mediating Artifacts available to the *Student* may differ from those available to other students inhabiting a different learning environment. As shown in Fig. 2, after the *Student* graduates, the

STEM knowledge he shares with the world will, in turn, shape his Community (he is a role model to others) and Division of Labor (he becomes a college professor).
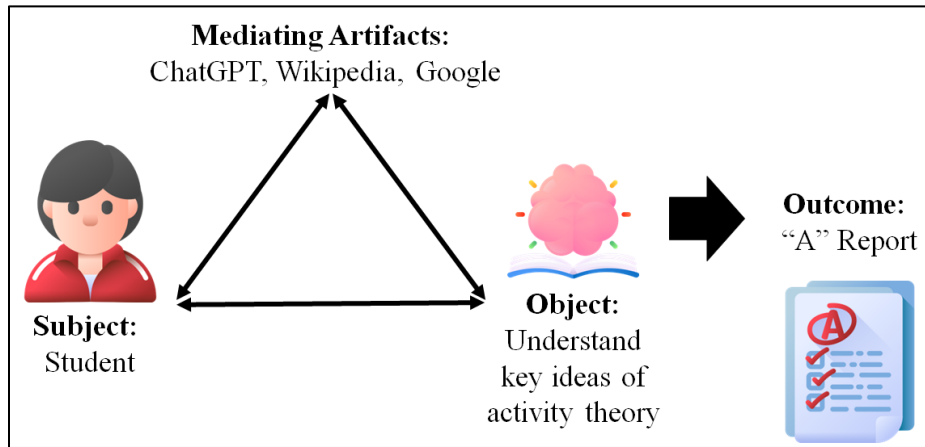

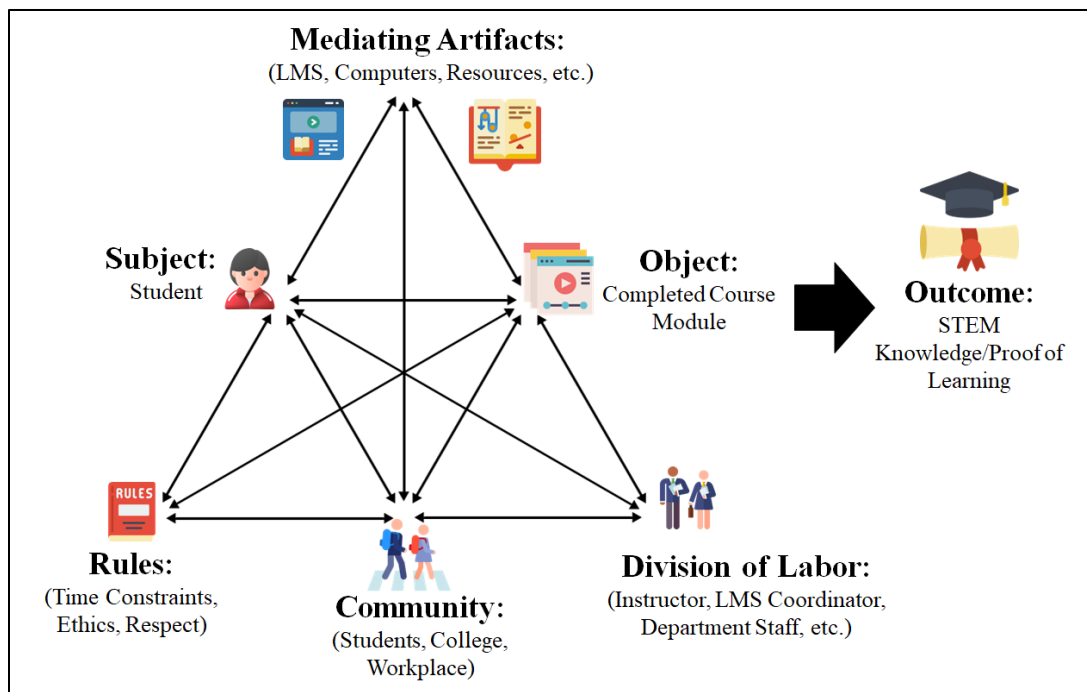*Figure 1. Simple Activity Model (Subject, Mediating Artifacts, Object, Outcome)*

Figure 2: Extended Educational Activity Model

Other Mediating Artifacts used in educational settings may include:

- **Surveys:** In a CRM context, surveys can be conducted at strategic touchpoints. Surveys might solicit student and teacher feedback on the question posed earlier – Is the teacher too hard or are the students too coddled? Surveys might solicit feedback relating to personal, cultural, societal, or other factors impacting the teacher and student experiences in the learning setting. Some key points need stressing: i) Surveys should have clear-cut goals supported by the organization; ii) Surveys should be optional and responses confidential. Reported results should be aggregated to protect anonymity; iii) Well-timed, attractive CRM

incentives can increase response rates and feedback quality; iv) Short surveys are best; v) Surveys should be designed for scientific analysis. Detailed guidance on how to create scientific surveys for educational settings can be found in [18].

- **Interviews:** The surveys may point to matters that need further investigation. Interviews may be useful in drawing out feedback to clarify survey responses, and to explore questions such as: What changes, if any, do you think are needed in the course delivery? Do you need any help? Here are key points to keep in mind: i) Interviews should be short, focused, and voluntary; ii) Interview results should be anonymized and codified so they are amenable to statistical analysis; iii) A trained, neutral third-party should conduct the interviews. However, there may be times it makes sense for the teacher to talk directly with their students. Rules of engagement for teacher-student interactions should be well-defined, and it may be helpful to have a moderator assist with interviews. All parties must trust that their personal boundaries will be respected, and they will not face retaliation for being honest.

- **Discussion forums:** Discussion forums connect learner and instructor communities so they can easily help each other and share ideas and information as needed. When students post and reply to messages, and read the messages of their peers and give them feedback, this improves the quality of the learning environment dynamics and the richness of the content delivery.

- **Community Policies:** These specify rules and standards of ethical behavior that must be followed. These should be shared with teachers and students at the start of the program. This helps to avoid confusion and inappropriate behavior. Web-based learning requires more internal self-regulation and external supervision. Community policies can provide a schema to help keep specific learning groups engaged in their online courses from beginning to end.

In an educational context, the Activity model is a reminder that many factors impact student and teacher performance, and they are often beyond their respective spans of control. Activity models can capture multiple levels and dimensions, much like a CAD (Computer Aided Design) diagram. Models can portray versions of "current reality" and "imagined reality." Noted child psychologist and educational reform advocate, Dr. Seymour Sarason, wrote extensively about the need to create productive contexts of learning [19], [20], [21], [22]. Activity Theory is a comprehensive, visual, extensible, fluid approach for modeling environmental settings. The results can help determine the LMS-CRM objectives that will be implemented in a live educational setting. It can capture a big-picture view of the CRM project scope in relation to the overall learning environment, and remind us of what is missing and the limits of our knowledge. This encourages us to ask: What is a school system and what does it encompass? Activity theory helps us create a strawman to elicit debate and consideration of the internal and external interrelationships and interdependencies influencing the learning setting. This helps to visualize the amorphous, complex ecosystem within which schools operate, and broadens our perspective on where systemic improvements may be needed to improve learning dynamics.

Managing the LMS (Learning Management System) and CRM (Customer Relationship Management) System Development Process

When building a LMS-CRM system from scratch, the first step is to select and deploy the LMS. The second step is to create learning content and upload it into the LMS. The third step is to implement the CRM system. This is a three-stage systems development project. The System

Development Life Cycle (SDLC) is a process for managing information system projects from beginning to end. There are many renditions of the SDLC process, including the Waterfall model, Agile Model, Scaled Agile Framework (SAFe), and Capability Maturity Model Integration (CMMI) [23], [24], [25], [26]. It is beyond the scope of this paper to discuss different SDLC project management approaches in detail. The Waterfall model is a widely used approach that is suitable for managing the three stages of the LMS-CRM project. As shown in Fig. 3, the Waterfall model is based on six (6) successive project phases: feasibility and requirements analysis, design, implementation, testing, deployment, and maintenance. Project feasibility should be assessed before starting implementation. This involves identifying potential landmines (scope creep, technical difficulties, legal implications, cost overruns, other pitfalls), developing strategies for mitigating risk, and estimating the likelihood of success. The time, money, and effort required to complete each phase depends on the project scope and other factors determined on a case-by-case basis. A designated team of decision makers, end-users, and technical staff must work together through each phase. After a working LMS-CRM system is in place, an Agile model may be appropriate to manage on-going system upgrades. The Agile model is an incremental, iterative, collaborative project management approach designed to deliver quick results. This is shown on the right in Fig. 3. To recap, implementing a Learning Management System with CRM capabilities requires good project management from beginning to end. There are many SDLC approaches that can be used to guide the process, and it may be desirable to change the approach over time. Project success relies on having a team qualified to pick the best approach given organizational constraints, personnel experience, budgets, goals, and resources.
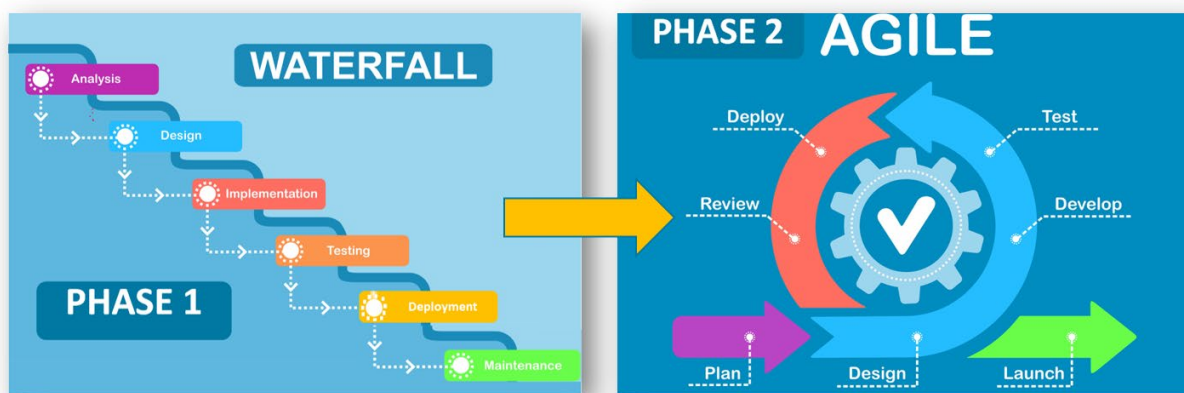

Figure 3: Overview of System Development Life Cycle Process (Waterfall and Agile Models)

Implementing CRM (Customer Relationship Management) Capabilities

Assuming the project is approved after the feasibility analysis, the ultimate goal is a LMS with a functional CRM system, shown in Fig. 4. Different educational settings and programs may implement this in whole or in part, depending on their unique requirements. The CRM system consists of two major elements. The first element consists of user touchpoints and incentive delivery mechanisms. The LMS provides a natural interface for system users, and powerful tools for automated data collection and electronic delivery of incentives. Other touchpoint options include text messaging, email, mobile applications, and web-based portals. Special APIs (Application Programming Interfaces) and other technology solutions may be needed to collect

and integrate data collection across all touchpoints. This is especially true if different systems, device types, and vendor solutions need to work together.

The CRM element consists of an IT infrastructure and system databases, with these features [4]:

- **Data privacy rules**: These define access controls used to protect data confidentiality, integrity, and availability (CIA). This includes legally mandated data protection. Rules are used to enforce cybersecurity best practices by: i) controlling access on a need-to-know basis; ii) ensuring collection of personally identifiable information (PII) and other sensitive data is limited to well-defined, approved purposes; and iii) anonymizing and encrypting PII and other sensitive data at rest and during transmission.
- **System security**: Various administrative, physical, and technical safeguards must be in place to provide a layered, robust cybersecurity defense of system and data components.
- **Closed-loop CRM system design:** The status of each user interaction with the system must have a clearly defined state. If user feedback is solicited at a system touchpoint, the response or nonresponse is recorded. If an incentive is offered, the system records if it is accepted or not. A closed loop system is an essential requirement for scientific studies on user behaviors and preferences, and provides the foundation to conduct randomized controlled trials.
- **Decision engine:** This component uses algorithms and pre-determined rules to control the delivery and processing of incentives.
- **Data warehouse:** This is where user data are stored and optimized for CRM, statistical analysis, and reporting functions.
- **Reports and analytics:** User and system data are analyzed with statistical techniques and results are displayed in reports. Specialized statistical, data mining, and data visualization software supports this function.
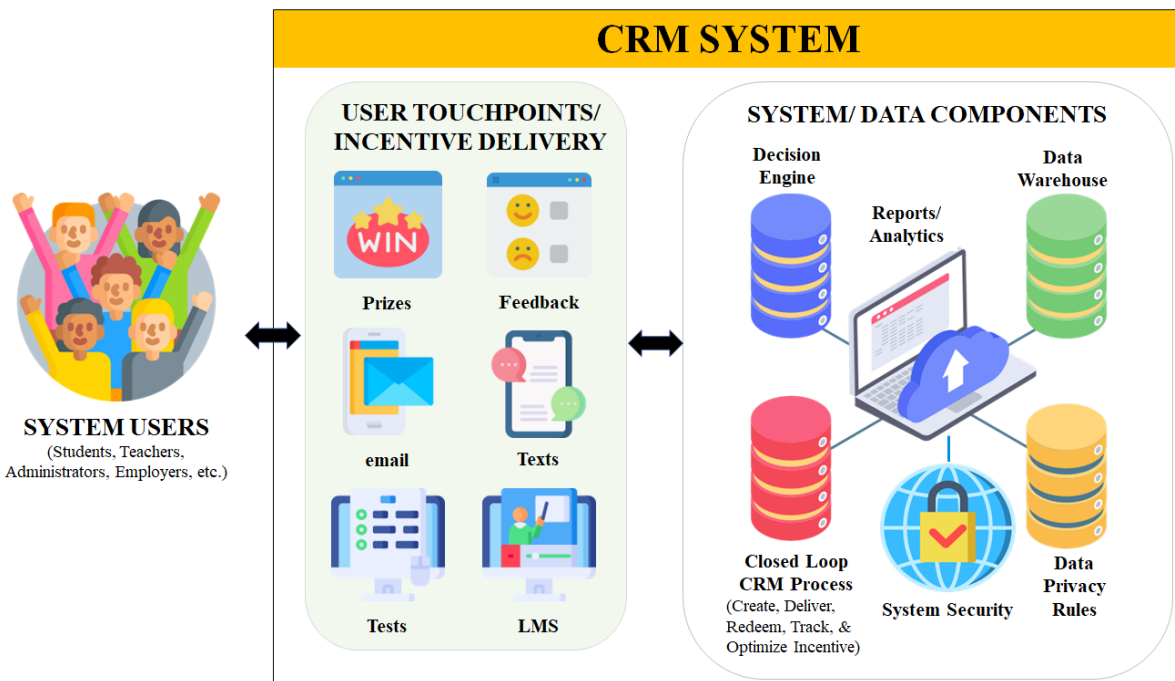

Figure 4: Overview of Educational CRM System

Let's review how the CRM elements fit together. Data on user actions, responses, and behaviors are collected at CRM touchpoints. The data are analyzed using scientific methods. Reports are generated and reviewed with appropriate program participants (decision makers, teachers, students, other stakeholders) to inform decisions on how to improve programs, courses, and student, teacher, and organizational experiences. Ideally, implementing CRM processes will foster a culture of openness and a drive for excellence and continuous improvement across the entire organization.

The approach described here is an outgrowth of the authors' grassroot efforts to develop a CRM capability to augment online and blended after-school, college, and workforce training programs created in collaboration with educators around the world. Every school we work with is unique, and every school has this in common: stretched staff, limited IT resources, strained budgets, and inspiring, dedicated administrators and teachers who look for ways to do more for their students with less. We developed the educational CRM system architecture illustrated in Fig. 4 incrementally by starting with small pilot projects championed by administrators with decision-making authority and technology-savvy teachers. We used the Waterfall model to manage the initial system rollout, and use an Agile model to manage on-going rounds of major system upgrades. The LMS-CRM system was built on a shoestring from the ground-up using low-cost or free opensource software. It is standalone and requires little or no change to existing school IT infrastructure, processes, or procedures. This was a key factor in getting the project approved. The system is capable of importing and exporting data feeds in spreadsheet form. After appropriate reviews and approvals, the system is modified as new requirements and technological solutions emerge. There are several versions of the "LMS-CRM system," each using a different LMS platform (Canvas, Moodle, Adobe Prime, others). Finding incentives that are cost-effective for the school and attractive to the students is not easy. One of the more effective incentives is giving the student the power to express their needs and suggestions and to know their voice will be heard. This is not a cure-all. Nonetheless, we witnessed transformational personal growth in some students who were at high risk of dropping out after they were actively encouraged to become part of the solution instead of the problem. CRM can be empowering.

In a recent post – "Miss Manners: Professor disagrees with colleagues on handling student excuses" – a college professor expresses frustration with his unmotivated, unprepared, disengaged students who send him a "constant stream of emails" with lame excuses for skipping class ("I wasn't feeling it," "I was too hung over,") and not doing their assignments ("I've been in a funk all weekend so I didn't manage to do the assignment on time, but can I still turn it in?") [27]. He asks, "Is it not fair for me to find these emails unusually casual and personal for the student/instructor dynamic? Is it really my responsibility to assume details about students' lives and refer them to services they didn't ask about and with which I am not familiar? What I found rude was my colleagues' pushing so hard against me…when I complained about this email, …[they] said I should have offered her information about counseling services [27]." Miss Manners was sympathetic and opined that among the factors contributing to this are "universities thinking of students as customers who should be satisfied; and the general litigiousness of society. Your concern should not be whether your students come to class but whether they master the material and fulfill the assignments. Unless they are exhibiting bizarre behavior that should be reported to mental health experts, the rest of their lives are not your business…. you

may not have the support of the university in grading students according to their achievements or failures to perform [27]."

Several observations can be made about this exchange, when viewed from a CRM perspective:
- **The Professor:** needs to communicate his questions and concerns to appropriate school personnel. He may find he is not asking the right questions or seeking the best solutions.
- **The Students:** need to communicate their difficulties (including excuses) to appropriate school personnel, especially if their studies will be seriously impacted if they do not get help.
- **The Administrators**: need to communicate official positions and policies (grading, student absences, student referrals, instructor responsibilities, support resources, other rules) to students, teachers, and others.
- **Emotions**: A range of emotions are in play, including fear, frustration, hurt feelings, indignation, confusion, and more. Non-tenured and adjunct teaching staff may have little or no job security, and they may be afraid they will be dismissed or become a target because what they or their students say is unpleasant or difficult to address. Although it may be helpful to understand the emotional state of *Subjects* (students, teachers, administrators) in the environmental setting, the emotions expressed per se do not lead to an objective determination of the true dynamics in play and the statistical significance of their impact and frequency. Conclusions based on anecdotal speculation may not be valid, and they lack the specificity needed for actionable, systemic change.
- **Miss Manners**: is not in a position to give informed advice or take meaningful action on behalf of the professor. She did not cite scientific evidence or pedagogical best practices to support her belief that *it is a problem* if universities think of their students as customers who should be satisfied, and *it is not a problem* if students aren't coming to class. It is important to distinguish opinion from fact. The same is true for her belief that the university may not support the professor if he gives grades that accurately reflect his students' achievement.

A Customer Relationship Management system can support multiple approved channels for communication that can be used any time and at designated touchpoints. The communication can be anonymous if people do not want to give their name. The CRM can support objective statistical analyses and data mining studies. This allows exploration of innumerable questions, such as: What factors are in play when students have trouble completing assignments? What factors are in play when teachers are successful in getting their students to complete assignments? The issues the professor raised are universal. A well-crafted CRM could address many of his concerns, if it is also supported by meaningful action on the part of the school, and a culture that embraces Deming's tenets of Total Quality Management (improve constantly and forever; drive out fear; put everybody to work accomplishing the transformation) [28].

Here are a few examples of well-known schools using LMS and CRM systems, although they are not using them in the same way suggested here:
- **Harvard University**: The Slate (Strengthening Learning and Teaching Excellence) CRM system is used to provide professional development, consultations, and instructor resources. The Canvas LMS is used as a centralized learning and communication platform [29], [30].
- **Stanford University:** The Salesforce CRM and the Canvas LMS are used to manage school operations and deliver online courses [31], [32].

- **University of Michigan:** The Salesforce CRM is used to manage and track companies and organizations outside the school seeking help, faculty and staff, students, alumni, and internal communications. Canvas is used as their LMS [33], [34], [35].

In addition to Salesforce CRM, and Slate, mentioned above, other commercial educational CRM platforms include: HubSpot CRM, Microsoft Dynamics 365, Pipedrive CRM, and Zoho CRM.

In sum, integrating a CRM capability within the LMS can be a complex technical challenge. It requires careful planning and expertise. It is important to carefully consider the functional and technical requirements, and potential roadblocks, before embarking on a LMS-CRM project. It is a worthy endeavor with many potential benefits. The LMS-CRM system provides a way to rise above beliefs, complaints, and speculation. It is a tool for clarity and informed decision making.

Using LMS (Learning Management System) and CRM (Customer Relationship Management) Generated Analytics

Learning Management Systems vary widely in their features, functions, and system requirements. As cautioned earlier, a thorough requirements analysis should be conducted before settling on a particular platform. Table 1 lists common features found in basic to high-end systems.

Table 1: Common features found in basic to high-end LMSs (Learning Management Systems)

LMS Features	Basic	Intermediate	Advanced	High-End
Resources/Courses	✔	✔	✔	✔
Syllabus	✔	✔	✔	✔
Gradebook	✔	✔	✔	✔
Plagiarism (Turnitin)	✔	✔	✔	✔
Tests/Quizzes		✔	✔	✔
Default Reports			✔	✔
Social or Peer-to-Peer Learning			✔	✔
Learning Plans				✔
Data Analytics				✔
Data Mining				✔

Depending on the Learning Management System and its implementation, data can be collected on a variety of metrics, such as:
- Achievement data
  - Achievement badges
  - Course completion rates
  - Module level data
  - Quiz attempts
  - Quiz scores by module/questions
  - Skills mastered

- o Time spent on individual courses/modules
- o Training progress
- Communication data
  - o Announcements
  - o Automated notifications
  - o Learner feedback
  - o Peer-based feedback
  - o Teacher feedback
  - o Support emails
  - o Reminders
- Demographic data
  - o Age
  - o Economic characteristics
  - o Race
  - o Sex
  - o User group (school, classroom, course)
- Usage data
  - o Attendance reports
  - o Login information (to check active users)
  - o Resource utilization (frequency, date, time, duration)
  - o User visits

In totality, these metrics hold a wealth of knowledge about the student's learning experience. Even a single metric can provide actionable insights on the student's learning progress, course difficulty, quiz difficulty, and question difficulty. Consider the case of employees working for a DoD contractor. They are required to take cybersecurity training as a condition of employment. To pass the course, they must get a 100% score on the final quiz. The passing score is stringent because if they fail to learn all the material, a hacker might exploit their lack of knowledge to launch a successful cyberattack on their employer. This might even compromise national security. Employees are allowed multiple attempts to pass the course. However, after every three failed attempts, the course instructor schedules an intervention to review the material with the employee and give them extra help. Fig. 5 shows the results of four (4) new employees who have completed a competency-based course entitled "Introduction to Cybersecurity." The graphs show everyone needed multiple attempts to get a 100% score. Learners 1 and 3 showed steady improvement in their score each time they repeated the quiz. Learners 2 and 4 had inconsistent gains and losses on each attempt, and needed more help and more tries before passing the course.
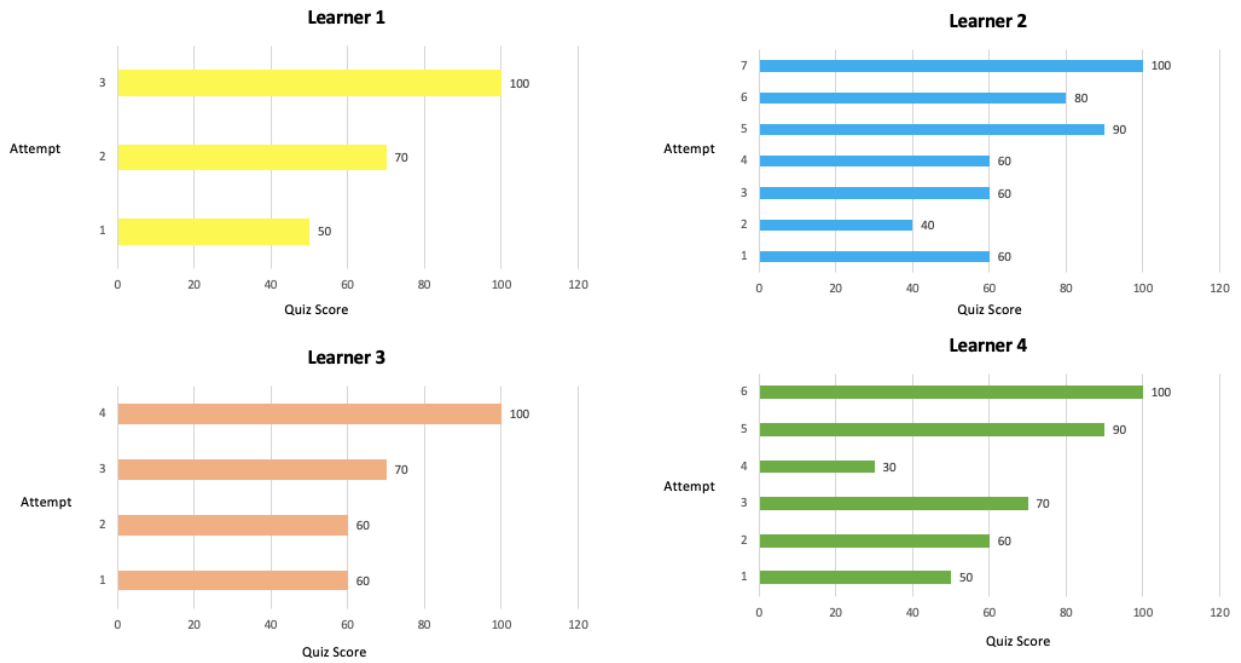
Figure 5: Number of quiz attempts needed to get 100% score

Let's look at the same variable from another perspective. Fig. 6 shows the average number of attempts needed to pass the final quiz computed across all employees. It shows the Phishing and Password Security courses are the hardest to pass, and Social Engineering is the easiest.
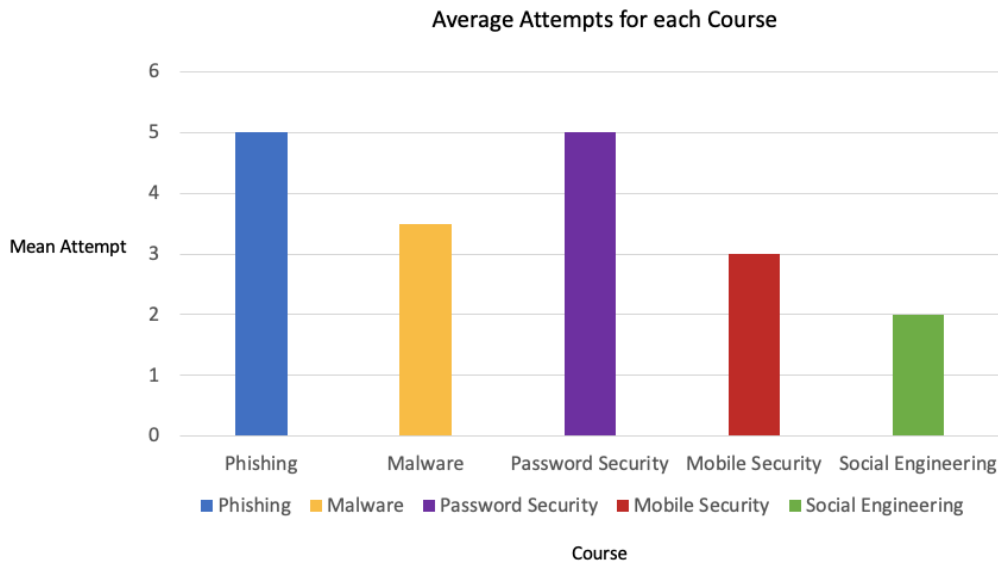

Figure 6: Average number of attempts needed to get 100% for every cybersecurity course

Attempts as per Question for Phishing course

Attempt	Question 1	Question 2	Question 3	Question 4	Question 5	Question 6	Question 7	Question 8	Question 9	Question 10
Attempt 1										
Attempt 2										
Attempt 3										
Attempt 4										
Attempt 5			10							
Attempt 6			10							
Attempt 7			10							

Learner A

(Bar chart — Score vs Attempt Number)

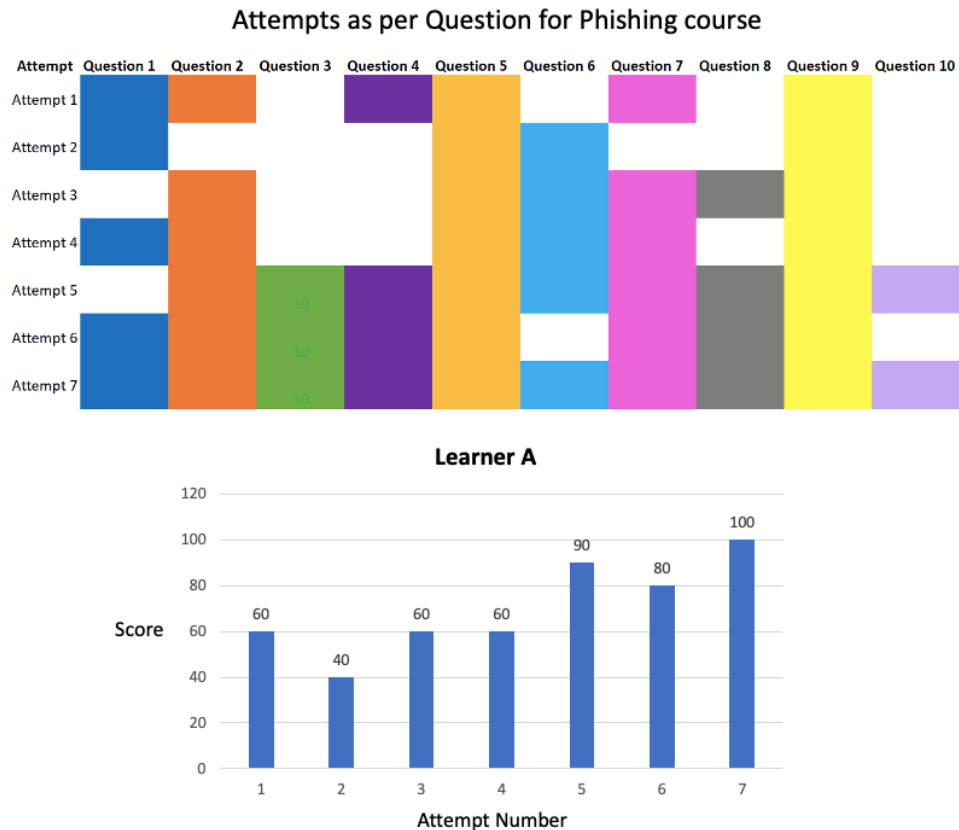| Attempt Number	1	2	3	4	5	6	7
Score	60	40	60	60	90	80	100

Figure 7: Number of attempts Learner A needed to get each question right in Phishing course

Next, look at Fig. 7. It focuses on a single learner taking a Phishing course. The bar chart at the bottom shows it took Learner A seven (7) attempts to pass the quiz. The multi-colored tiled graph on top shows what happened during each attempt. On the first attempt, Questions 1, 2, 4, 5, 7 and 9 were answered correctly. On subsequent attempts, only Questions 5 and 9 were answered correctly every time. Question 10 was especially hard for Learner A to get right. When considered together, this is suggestive Learner A had trouble comprehending the course material.

Other metrics can help identify struggling students (consistently low assessment scores, periods of inactivity, high course drop-out rates, student feedback, statistical and data mining results). The LMS can be used as an early warning system for teachers alerting them when they have students that may need personalized support and other resources to help them with their courses.

ADDIE is an Instructional Design model consisting of five (5) sequential phases: **A**nalysis, **D**esign, **D**evelopment, **I**mplementation, and **E**valuation. ADDIE is a widely used, flexible, systematic approach for designing and developing high quality course materials and learning experiences [36], [37], [38]. ADDIE starts by defining course objectives and goals, and then analyzing the students' learning needs. This is used to guide the design, development, and implementation of course materials. This is followed by an evaluation of the effectiveness and quality of the course and associated materials. The ADDIE process may reveal strengths and weaknesses in the way the LMS is used to organize and deliver online content, and how it

collects and tracks learner progress data. The LMS-CRM, in turn, can support the ADDIE process in a number of ways:

- **Analysis**: The LMS and CRM can provide data and analytics on students' performance, knowledge gaps, skill deficiencies, learning preferences, and course progress. Instructional designers can use this input to design personalized learning content.
- **Design:** The LMS is a platform to organize instructional content, including videos, student handouts, quizzes, and other resources. Instructional designers can use templates, themes, and features built into the LMS to design an engaging learning environment.
- **Development:** Instructional designers can upload learning materials into the LMS so they can be tested, evaluated, and refined before being released to students.
- **Implementation:** When the LMS is live and delivering content, it can collect a variety of metrics related to the student's learning progress and experiences, as described earlier. Statistical and data mining algorithms built into the CRM can provide deeper insights on collected data.
- **Evaluation:** The LMS collects student feedback, and data related to the students' learning progress that can be used to evaluate the students' knowledge improvement and the course effectiveness. The CRM can also collect feedback from students, teachers, administrators, and other system users for evaluation purposes. Evaluation standards – such as QualityMatters (QM) and OLC Quality Scorecard [39], [40] – complement the evaluation process by providing metrics on the overall program quality. The National Institute of Standards (NIST) has published guidance on how to evaluate training programs, especially those dealing with technology and cybersecurity, which may be useful in evaluating training quality [41].

There are many alternatives to the ADDIE Instructional Design (ID) model. There is no definitive consensus on which and when different approaches should be used. This is a rich area for research and exploration. It is beyond the scope of this paper to review the different Instructional Design models in detail. Briefly summarizing, some of these include:

- **ACAD** (Agile, Collaborative, ADDIE-Modified, and Design-Thinking): This is a cyclical ID model that emphasizes collaboration, flexibility, iteration, and continuous feedback. It is "a meta-theoretical framework for understanding and improving local, complex, learning situations… [It was developed for] situations where close supervision by teachers at learn-time is difficult or impossible… This activity-centred approach distinguishes ACAD from design approaches that are teacher- or instructor-centred, content-centred or technology-centred [42]." ACAD has been used to design Computer Supported Collaborative Learning environments (CSCL), and has been shown to offer these benefits: (1) ease of implementation, (2) extensibility and adaptability, and (3) tool to capture learning actions in various social and cultural contexts [17].
- **ARCS** (Attention, Relevance, Confidence, and Satisfaction): This ID model is designed to enhance and maintain student motivation. It focuses on these factors: Attention (Perceptual Arousal, Inquiry Arousal, Variability); Relevance (Goal Orientation, Motive Matching, Familiarity); Confidence (Learning Requirements, Success Opportunities, Personal Control); and Satisfaction (Intrinsic Satisfaction; Extrinsic Reward, Equity) [43].
- **Dick and Carey Model**: This is a ten (10) step ID model that is popular in schools and other educational settings. The steps are: 1) Identify instructional goals; 2) Conduct instructional analysis; 3) Identify entry behaviors; 4) Write performance objectives; 5) Develop

assessment instruments; 6) Develop instructional strategy; 7) Develop and select instructional materials; 8) Design and conduct formative evaluation; 9) Design and conduct summative evaluation; and 10) Revise instruction [44].

- **Gagne's Nine Events of Instruction:** This ID model is designed to create instructional events that help students focus on their learning goals. It is based on how people process information and absorb mentally challenging lessons. The nine (9) learning events are: 1) Stimulate interest; 2) Inform learners of objectives; 3) Stimulate recall of prior learning; 4) Present the content; 5) Provide learning guidance; 6) Elicit performance; 7) Provide feedback, 8) Assess performance, and 9) Enhance retention and transfer [45], [46], [47].
- **SAM (Successive Approximation Model)**: This is a simplified version of the ADDIE model. It consists of a three (3) step iterative process involving: Preparation; Iterative design, and Iterative development [48].
- **Understanding By Design (UBD):** This is a backward ID process to ensure learning outcomes and assessments align with the overall course goals and objectives. The first step in the process is to identify the desired results. The second step is to determine acceptable evidence of learning. The third step is to plan and develop effective learning experiences and instruction [49].

Creating effective, engaging, learner-centered content — especially in difficult STEM domains — is inherently difficult. Nonetheless, these difficulties must be overcome to provide high quality course content and learning experiences that "teach the student, not the subject matter [20]". Instructional Design (ID) models are an important tool in meeting this challenge. There are many ID models from which to choose. The choice is best left to qualified Instructional Designers who are familiar with the student, teacher, school, and course requirements. Effective use of ID models requires deep knowledge about the learners and the dynamics of the learning environment. The raison d'être of the LMS-CRM system is to help supply this knowledge. The goals of the ID model and the LMS-CRM system are mutually supportive and complementary.

In sum, a Learning Management System (LMS) is a powerful platform to organize and deliver course content. It can collect extensive data on the students' learning experiences, encompassing student progress, learning analytics, performance metrics, learner engagement metrics, feedback, and course completion data which may be needed for legal compliance purposes. The LMS can support the Instructional Design process and help in the creation of high-quality learning content and learning experiences. The CRM component enhances the learning environment in a number of ways: i) it can assist in the design and development of personalized course content based on individual learner needs, preferences, and feedback; ii) it can provide statistics on learner behaviors and preferences to help identity useful incentives to maintain engagement and opportunities for potential improvement in course delivery; and iii) it opens new communication channels to share information and feedback between students and teachers.

Challenges and Limitations Using CRM-Augmented LMS Systems

The first author's forays integrating CRM capabilities into technology infrastructures began in the 1990s, as a lead designer of CRM systems for large commercial companies. The purpose of these systems is to maximize profit and customer retention. They do not use LMS technology. The projects are justified based on their ROI (Return on Investment), which is achieved by

increased profits generated by the CRM activities. The projects have strong C-level management support and multi-million-dollar budgets. This level of top-down support helps resolve inevitable bureaucratic and political obstacles facing the development team, although it does not eliminate them. Project coordination and logistical issues are significant challenges in these large-scale, multi-year projects. The projects usually involve major organizational process re-engineering, and new Information Technology infrastructure and systems to support the data processing, described in Fig. 4, at customer touchpoints. Some companies lack direct access to their customers because their products and services are sold through intermediaries, and the intermediaries do not want to give up their strategic hold on customers by supporting the CRM efforts. The companies then have to find creative ways and reasons to establish direct lines of communication with their customers.

CRM is a mature technological approach, and with a strong technical team and management support, large-scale initiatives can be highly successful in meeting business objectives. Many companies – not just Google, LinkedIn, Facebook, and Amazon – base their business model on a CRM foundation. Each person has a unique constellation of characteristics, behaviors, and preferences, which if captured, can be used to create a personal profile. CRM's microtargeting exploits this by creating customized products, services, and/or marketing appeals based on these individual variations. This contrasts with traditional mass marketing which targets consumers based on macro-level characteristics representing "most people." CRM's usefulness is not limited to marketing-oriented companies. According to the International Organization for Standardization (ISO) 9001 standards, customer relationship management is the foundation for any organization that wants to implement quality management systems [50].

CRM's global reach is awe inspiring and hard to grasp. Its success is also a cautionary tale of abuse, fraud, and compromised data which is often collected surreptitiously without the consent or knowledge of the consumer. Data brokers are part of the CRM universe, and they have their tentacles all over consumer online activities. Internet sessions are tracked and used to create detailed profiles of viewing habits and preferences and the information is sold to various partners and advertisers who bid on the information. "That's why you get those creepy ads in your Instagram feed or on websites that seem to know what you were just talking about [51]." It is next to impossible for the consumer to opt out of the data collection. Legislation may be the only way to curb these egregious practices.

In the 2000s, the authors began collaborating with high schools, community colleges, universities, non-profit organizations, industry sponsors, and/or training companies to build LMS-CRM systems. The LMS-CRM project teams are usually comprised of high-level administrators and/or program directors, college and university faculty, teachers, a Chief Information Officer (CIO) and Information Technology staff, cybersecurity experts, statisticians, data mining specialists, a LMS Administrator, and Instructional Designers. Parents and students are engaged in advisory roles and help with feedback on system usability and content design. Institutional Review Boards (IRBs) and legal advisors may also be involved.

In contrast to the commercial CRM projects described above, these projects are not created to make money. They involve a lot of volunteer and pro bono work and are driven by an altruistic desire to help students do their best in school. The specific goals of the LMS-CRM projects vary.

Here are some representative examples: i) Demonstrate proof that the sponsor and grant funding requirements, and desired outcomes, have been achieved by the learning program; ii) Provide engaging, enjoyable STEM courses and activities to stimulate student interest in the subject matter; iii) Introduce students to a variety of career options and show them the connection to their school studies and future success; iv) Offer enriched learning experiences and vocational training and observe long-term outcomes associated with student participation; v) Provide mandatory cybersecurity job training and proof of mastery and course completion for government compliance purposes; vi) Develop high quality Health Information Technology (HIT) e-learning programs for teens, and vii) Help students succeed in their studies and complete degree requirements. The projects are designed to integrate a CRM capability with an LMS that is used to deliver course materials. These projects have well-placed project champions and are justified based on their alignment with the goals and requirements of project sponsors. The development team faces few bureaucratic and political obstacles because the project efforts are self-contained and within the purview of the program sponsor or champion. Project coordination and logistical issues are usually limited (compared to commercial projects) because the projects are small and do not require organizational restructuring. They typically have minimal or no impact on current processes and systems. All the projects are protected by non-disclosure agreements. For this reason, specific details (such as organization names, number of participants, demographic data) are omitted from the discussion in this paper.

Here are insights the authors have gleaned on the challenges and limitations using LMS-CRMs in schools and other learning settings:

- **Challenges:**
  - **Competing priorities:** Schools must meet performance (e.g., Common Core State Standards) and/or accreditation standards, while teaching students and preparing them for college entrance exams (SAT, ACT) and other standardized tests. These efforts are ongoing and demanding, and may leave little time to support other initiatives.
  - **Lack of basic resource**s: The schools most in need of a LMS-CRM system are usually the ones least able to implement them. Many k-12 schools lack the necessary prerequisites (access to computers, high-speed Internet). It will take time before this situation changes. The organizations the authors work with have excellent technology resources and technical support staff**.**
  - **Lack of familiarity:** School administrators and teachers may be unfamiliar with the concept of CRM and how it can improve the learning environment – for them and their students. This can contribute to reluctance to get involved with LMS-CRM projects.
  - **Funding:** Funding for these projects is usually of limited duration. It is a constant challenge to find new sponsors and grants to maintain sustained cash flow. This limits the size and scope of the projects the team can support. It also means support for the LMS-CRM can end at any time due to lack of funds, even though the project is successful by other measures.
  - **Hands-off attitudes:** Typically, teachers and students do not have much voice in determining school policies, priorities, and new projects. This may contribute to a lack of engagement and sense of personal responsibility for the LMS-CRM efforts, especially since these projects are outside their mainstream school responsibilities.

- **Resistance to change:** Teachers who are not part of the project team may be wary and reluctant to get involved because they do not want to change their teaching style or the teaching materials they use. They are afraid of being tasked with more work to create "engaging" course materials for online delivery, and feel this should be the job of an Instructional Designer. The authors are reminded of the "old days" when typing was done by secretaries and typing pools. They prepared reports, messages, school flyers, mail - anything and everything that needed to be typed and copied on carbon paper. When personal computers and Word processing software became available, the typists were laid off and people had to learn to type for themselves. Many reacted with horror and anguish, and felt they had been demoted. With time, people have adapted. This evolution required training, time, technical support, and a change in mindset. The same is true for LMS-CRM projects. It is also important to acknowledge that the teachers' concerns are valid. Perusal of the over four-hundred pages of the *Toolkit for Evaluating Alignment of Instructional and Assessment Materials to the Common Core State Standards* helps one appreciate the challenges of creating instructional materials and conducting the assessments to assure they meet quality standards [52].
- **Privacy concerns:** Schools are notoriously bad at protecting data, making them a favorite target for hackers. The K12 Security Information eXchange (K12 SIX) organization maintains a continually updated map showing where k-12 schools have experienced cyber incidents. The map vividly displays pervasive problems [53]. The situation at HEIs is similar. The LMS-CRM must not become another source of vulnerability for hackers to compromise. The LMS-CRM project can be an opportunity to address security vulnerabilities in the school environment as a whole. No system can be made 100% secure, and the likelihood of cyber-attacks is high. Knowing this, the Information Technology (IT) and cybersecurity teams can take precautions to mitigate the risks of data compromise and limit the dangers posed by ransomware and other malware. An incident response plan needs to be in place to aid recovery efforts if a cyber incident or disaster occurs. With appropriate administrative, physical, and technical safeguards, schools can achieve a good level of security for their systems and data. Over 82% of breaches are caused by social engineering attacks and human error [54]. Training and awareness, and a security culture, can significantly reduce the risks of cyber incidents. Schools have legal, moral, and ethical obligations to safeguard sensitive and personally identifiable information and to obtain informed consent before collecting it.
- **Protection of intellectual property:** When instructional content is digitized and online, it is easier to copy and download. When copyrights need to be enforced, extra protections must be enabled in the LMS to prevent unauthorized access and copying. These controls do make it less convenient for students to access and use the course materials. Unfortunately, security is inversely proportional to convenience, and must be carefully balanced against system usability.
- **Sustainability:** Sustaining the LMS-CRM project is a major challenge given the rapid turnover in schools. It is relatively straightforward to implement a LMS-CRM when it operates as a stand-alone system. However, maintaining the system operation on an ongoing basis relies upon the continued support of the school champions and project sponsors. If they leave or retire, the system has to be introduced to their

successors, who may have other priorities. The lack of integration with mainstream school processes and procedures makes the LMS-CRM an "easy come, easy go" project even though considerable time and effort may be invested in creating it. This points to the need for systemic, institutionalized support of LMS-CRM initiatives.

- **Limitations:**
  - **LMS-CRM systems are not a magical cure-all:** The authors' work on LMS-CRM projects has humbled them. It has taught them to accept the reality that:
    - We cannot solve every problem;
    - We cannot satisfy everyone;
    - We cannot always agree on what is wrong or how to fix things;
    - Problems and unexpected events may occur which are outside our span of control and may derail the project;
    - We must ask difficult questions that defy easy answers before adopting LMS-CRM technology on a large-scale, such as: i) Who should own the CRM system and associated data? Schools, students, faculty, administrators, commercial enterprises, nonprofit organizations, and state, local, and federal entities may lay claim in whole or in part. What are the rights of the people about whom data are collected? ii) How will the LMS-CRM system impact power relationships? How does the power balance of project stakeholders impact the system design and how it is used? Who should benefit from the system? iii) What controls are needed to prevent misuse and/or abuse of the system? A well-designed CRM can significantly improve the educational environment and students' learning experiences. However, there is always the potential for system misuse. What limits should be placed on using Artificial Intelligence to deliver advice and offer incentives? How can we proscribe system nudging that might encourage unhealthy behaviors or choices that are not in people's best interests? iv) How can small projects be leveraged to support larger, more impactful educational reform efforts that could benefit from evidence-based, data-driven insights? What role can and should small LMS-CRM projects play in the larger educational ecosystem? These questions, and more, should be given careful consideration.

Summary and Conclusions

The National Education Technology Plan (NETP) is a call to action to leverage the power of technology to transform the educational landscape by [10], [11]:
- Delivering targeted interventions and tailored feedback based on learner data.
- Evaluating efficacy of new teaching practices and technologies based on student outcomes.
- Providing personalized, active learning experiences to all students.
- Building research-supported teaching practices and fostering professional development.
- Improving measurement of student learning against clearly mapped competencies.

LMS and CRM technology exists which can support these goals. In this paper, we have sketched a pathway to implement the technology in educational settings. Activity Theory can set the stage

by capturing a picture of the learning environment and the actors operating within its boundaries and their interrelationships. It can help map out a desired vision of the future.

The next step is to use the ADDIE process (or another Instructional Design framework — such as ACAD [42], Understanding By Design [49], etc.) in conjunction with a LMS platform to pilot a small project. This will develop the organizational capability to design high quality course content and to deliver it online. It takes time to learn the quirks, limitations, and features of the LMS, and to understand how to best use it in a particular learning setting. In the authors' experience, organizations that have a LMS rarely use it to its fullest extent. There are many reasons. However, in many ways it is analogous to buying a smartwatch. It has lots of features (GPS, fitness tracking, music, mobile payments, voice assistants, etc.) you will probably never use, and some you do not even know it has. Adopting a new LMS requires a significant investment of time and effort to master all the features and functions. A concomitant investment in building the organizational Instructional Design capabilities is highly recommended.

The next advancement is to integrate the LMS with a CRM capability. This adds another layer of complexity to the LMS. The project should follow the Systems Development Life Cycle from start to finish. Getting the project launched will require buy-in from visionary decision-maker(s) who are willing to make changes and take the associated risks. It helps if they have a budget. A team must be assembled with the requisite experience, expertise, and commitment to the project goals. The Department of Education cautions that you should start with a small pilot project [11]. This is good advice. It is advisable to pick one, or at most three, major goals that will drive the design of the CRM and the criteria for project success. The team needs quick and visible success with the project implementation. This means staying focused on practicalities, low-cost solutions, and meaningful results.

In conclusion, LMS-CRM systems aren't used widely, and there are challenges which must be overcome when implementing them. However, the reward for persevering is a deeper understanding of the dynamics between students, teachers, and their learning environment. This is a starting point for conversations on what the educational system of the 21st century should look like and how it should evolve to bridge gaps in disparity and mismatches with employer expectations. This should encompass serious debate and consideration of important questions about how LMS-CRM systems should be used, what rights system users should have, how and what data should be shared outside the immediate school environment, and what controls are needed and should be used to prevent system misuse. There are lots of opportunities for educational reform, and it may be difficult to achieve consensus on where to begin. LMS-CRM projects could play a part in informing these decisions. The authors are currently engaged in research to find ways of sharing LMS-CRM project results while protecting the anonymity and integrity of the findings. This is a subject for a future paper. Encouragingly, there are signs of a growing readiness for change and fresh ideas. Recently, Jacqueline El Sayed hosted an aspirational two-part workshop convening educators from around the world to consider ways of reimagining educational settings, so they are prepared to build the engineering workforce of the future [55]. It is inspiring to see great minds and dedicated educators committed to making this happen, and to be a part of this transformation.

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