The Medical Educator's Guide to Projects Leveraging Artificial Intelligence and Learning Analytics

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Introduction

Medical educators are enthused about the potential to leverage artificial intelligence, learning analytics, and other emerging technologies to improve medical training and promote precision education across the continuum of medical school, residency, and practice. However, many educators lack experience in developing and deploying such technologies. Collaborations with technical experts (in-house and/or commercial vendors) will be needed.

This guide outlines the core issues to consider when designing technological solutions. The contents may seem daunting to medical educators not trained in analytics and AI, particularly since capabilities in this space continue to evolve rapidly. This is why it is critical to assemble multi-disciplinary teams of people who bring complementary areas of expertise to such projects to ensure responsible development and deployment. This guide provides educators an overview of key points for discussion with their potential technical partners, facilitating essential details in planning and implementation that give projects the greatest chance at success.

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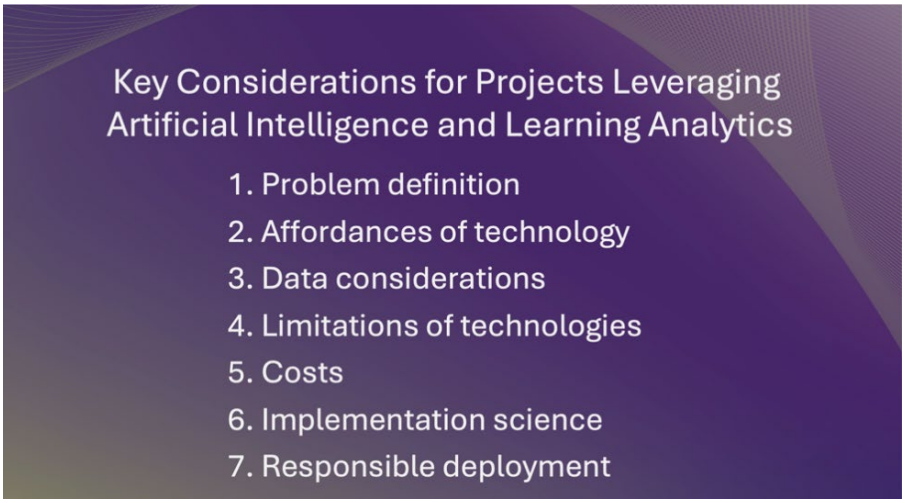


1. Problem Definition

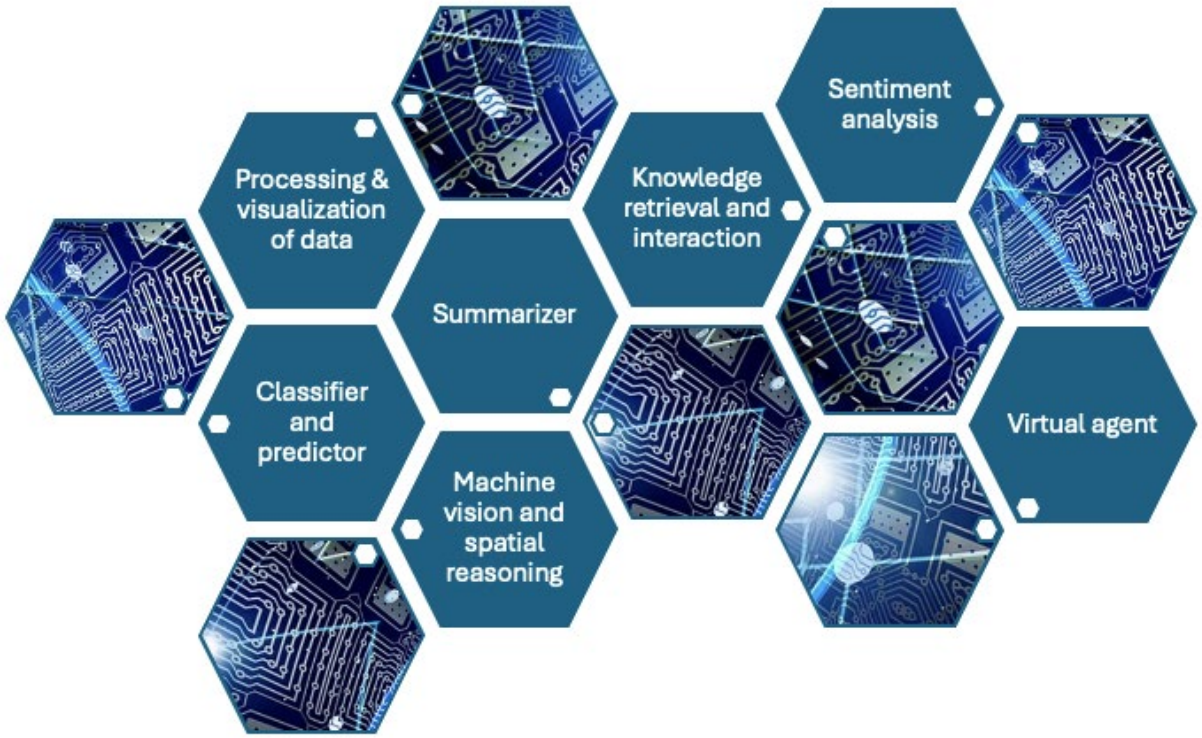
- *What problem are you trying to solve?*
- *What meaningful action will result from the proposed intervention?*

Educators are trained in backward design: first determining desired learning outcomes, then identifying the appropriate experiences and assessments needed to support those outcomes. A similar approach is needed in developing a technical solution to educational needs, but an intriguing technological advance can lure teams to instead seek a place to apply the "shiny thing," especially when approached by vendors with a solution to sell.

Clearly articulating what burden is to be relieved or what advancement is desired is critical to maintaining focus while broadening the range of potential solutions. Gathering input from stakeholders (learners, supervisors, patients) and engaging them in co-production will clarify how the envisioned initiative could make a meaningful impact upon the experience of those involved.

2. Affordances of Technology

- *What assumptions do we have about how to approach this problem?*
- *What specific technological capabilities could help?*



Examples of specific capabilities of artificial intelligence

We often hold preconceived notions about how to approach a given challenge. A common pitfall is to reproduce old models in new digital formats. While such an approach may offer convenience or efficiency, it is limiting. Emerging technologies should drive us to think entirely differently about a given task; educators may need to confer with those from other disciplines to fully appreciate possible solutions. Recent advances enable us to increase the volume and types of data we can capture, scale our capacity to process data, and offer new ways to synthesize data to inform meaningful actions.

At the same time, due to a lack of training in AI and data science, educators are at risk of envisioning AI as a magic wand that makes everything possible. We often lack knowledge to be specific regarding the capabilities that would be most useful for a given task. Because the field of AI is evolving so rapidly, capabilities are constantly changing. Active dialogue with technical experts, as well as engaging learners or other stakeholders in co-production, should avoid premature closure and can generate multiple possible solutions to the defined problem.

3. Data Considerations

- *What data is/could be available to address this problem?*
- *How will data be managed?*

For learners and supervisors to embrace data-driven technological interventions to improve education, educators must take deliberate action to promote trust in the quality, application, and protection of the data being used. Educators should ask about data provenance, measurement, and quality issues relevant to the use of a particular data source.

What data is available?

Solutions leveraging analytics and artificial intelligence rely upon rich data sets for training. Teams should consider what the data relevant to the desired outcome is, or could be, available. If one can anticipate meaningful patterns within a data set, AI could be a powerful tool.

What features within the data set are of interest?

Teams can predetermine specific data elements (referred to as features) of interest to be included in a tech solution. Are those features in structured data fields, or will it be necessary to create a process to extract them (such as natural language processing, NLP)? Monitoring the performance of an algorithm may reveal a need to change features or alter the weighting of features to fine-tune the tool. An advantage of applying AI to large data sets is the potential to identify unanticipated patterns. AI may reveal alternative features that impact outcomes. This capability could be particularly valuable in educational research to identify previously unrecognized factors associated with performance.

Is the data annotated?

When using a data set to train a model, we need to provide guidance regarding the outcome of interest to which features will be correlated. As a clinical example, if training an algorithm to review images of pathologic specimens to predict risk of cancer, the training data would include examples labelled as normal or abnormal. In education, we would similarly need to label data samples as correct/incorrect or some other dimension appropriate to the outcome of interest. Experts can be engaged to annotate sufficient samples, although this can be resource intensive. Developers also consider whether other existing features in the data set would represent the "answer." For example, if we seek to assess a learner's clinical appraisal of a patient from their clinical note in the EHR, the ICD and CPT codes registered by the physician of record for a given patient could be considered the "correct" answer to which the learner's work is compared.

Is the data representative of the population targeted for intervention?

Education teams must consider the alignment between the data that is available for development of a tool and the target population for deployment. For example, training an algorithm against expert performance may not provide nuanced understanding of appropriate novice performance among early learners. Technological solutions are not inherently biased, but the data sets on which they are trained — or the way that development teams identify features of interest — commonly have inherent bias that could be amplified by an application.

Is the data accessible to the education team?

Educational teams must consider access to sufficient data not only for initial training of an algorithm, but also for monitoring and continued refinement. If data is not directly accessible, what relationships should be pursued? Health systems commonly have dedicated units managing clinical data. Educators can connect with health system leadership roles such as chief medical informatics officers (CMIOs) or quality officers to explore possibilities for integration of educational applications with existing clinical data systems. Educators may underestimate the challenge of such integration. Application programming interfaces (APIs) facilitate this process, but teams should account for this process in project timelines and budgets. Potential federated structures that allow for training on data sets across institutions without sharing sensitive data can also be explored.

How will data be protected?

Educational applications could involve protected health information, learner data protected under FERPA, and data about supervisors and practicing health professionals. Such data is appropriate to use for educational purposes but must be protected. Educators must exercise caution that sensitive data is not exposed through integration of systems. The concept of an education data warehouse can be applied at the institutional level to support learning analytics or across institutions to support educational research.

Educators have a duty to ensure data will be managed appropriately and should ask technical colleagues or vendors how this issue will be addressed prior to pursuing each project.

4. Limitations of Technology

❖ *What limitations of the technology will impact this specific project?*

Educators may lack sufficient training to recognize potential risks or failures of a proposed technological solution. Educators should ask collaborators for explanations of these issues and work to create appropriate safeguards.

Common pitfalls include:

- Bias in data sets used for training and validation or bias in the process of data preparation
- Potential inequities in access to tools, application of tools, and outcomes associated with tools
- Technical issues, such as
    - non-stationarity of data

        Non-stationarity is a term that reflects the inconsistency in how health care and educational data may be recorded over time or in one setting versus another, impacting the performance of a model.

    - confounding inputs or label leakage

        When training an algorithm, if the labels of interest (e.g., correct/incorrect or normal/abnormal) inadvertently contaminate the data set such that the algorithm can "see" the answer, a model may appear to perform better than it actually does. One example of such **label leakage** was seen in a study of a tool to predict severity of illness by analyzing chest X-rays. The algorithm came to recognize that films taken in the supine rather than upright position indicated increased severity of illness. Once the algorithm indexed on that singular feature, it was not adding any new insights.

    - overtraining

        Overtraining refers to providing too much oversight during model development, resulting in lack of external validity when handling data beyond the training set.

- User error
    - Well-intentioned actors may misuse the technology or misapply its outputs due to a lack of training.
    - Malicious actors may deliberately tamper with a system to alter outputs.

An activity referred to as “red teaming,” in which stakeholders actively try to “break” the application, can be useful to anticipate pitfalls.

5. Costs

Educators may not understand the resources needed to develop and deploy such technological solutions. Input from experts will help to plan appropriate budgets for projects. Most projects to support precision education will require collaboration across units or departments that may not have existing relationships (for example, a medical education unit collaborating with a clinical informatics team). Establishing in advance which teams will provide each resource to a project will strengthen budgetary planning.

When negotiating with a vendor, educators should push for clarity around their business model to understand both immediate and long-term costs. They should also address whether the vendor will capture institutional data that could be used for other purposes.

Costs to consider include, but are not limited to

- Computing power/cloud services
- Programmer services
- Data management
- Subject matter experts for data annotation
- Statistical analysis
- Subscription and licensing fees, such as for large language models (LLMs)
- Integration costs (APIs) and IT effort
- Hardware (especially for AR/VR, augmented reality or virtual reality applications)
- Legal fees for contracts and data agreements
- Evaluation costs associated with continuous monitoring

6. Implementation Science

❖ *What change management strategies will be necessary for deployment?*

❖ *What is the context in which data is generated and in which the proposed tool would be used?*

Trust must be earned. It is important to consider the human-AI collaboration needed for an intervention to be successful. Teams should explore and specify the relationship and workflow between the educator, the learner, and the technology. The human-in-the-loop

concept requires that educational leaders deploying novel technologies embrace accountability and actively engage in monitoring tool performance over time. Learners interacting with new tools should be recruited to assist in co-production and monitoring of altered educational workflows as well as new technologies. To avoid the perception of a surveillance state, educators should ensure that data is used to benefit stakeholders. Educational teams should be transparent about the purpose of each technological solution, and leaders must demonstrate awareness of potential limitations.

Data-driven solutions are particularly vulnerable to context. Variations in workflows and stakeholder incentives impact the feasibility and accuracy of implementation. This is important when considering whether to buy an existing tool versus building a custom solution. If considering an existing product, educators should clarify whether the context for which the tool was originally developed algins with their intended use case.

Interpretability and explainability are common challenges of AI solutions. Developers, especially commercial vendors, may be hesitant to share proprietary intellectual property, but educators should press for an understanding of how predictions or recommendations are formulated. Increasingly, AI solutions are proactively designed to provide more insight into their own processes.

7. Responsible Deployment

- *Do all involved have adequate training for optimal use of the technology?*
- *Has the organization put appropriate structures in place for deployment and ongoing monitoring?*

Responsibility	Innovation project team	Educational administration (deans, curric cmte.)	Educator
PLANNING AND DEVELOPMENT			
Ensure the AI system addresses a meaningful educational goal	○		○
Ensure the AI system works as intended	○		○
Explore and resolve legal implications of the AI system[1] prior to implementation and agree upon appropriate safe, effective and equitable use of and access to education AI	○	○	○
Develop a clear protocol to identify and correct for potential bias	○	○	○
Ensure appropriate learner safeguards are in place for direct-to-consumer tools that lack educator oversight	○		
IMPLEMENTATION AND MONITORING			
Make educational decisions such as advancement and remediation		○	○
Have the authority and ability to override the AI system			○
Ensure meaningful oversight is in place for ongoing monitoring		○	○
Ensure the AI system continues to perform as intended through performance monitoring and maintenance	○	○	
Ensure ethical issues identified at the time of purchase and during use have been addressed[2]		○	
Ensure clear protocols exist for enforcement and accountability, including a clear protocol to ensure equitable implementation	○	○	○

Snapshot from the AMA guide Advancing AI in Medical Education through Ethics, Evidence and Equity

Educators pursuing technological solutions have a duty beyond the development phase to ensure responsible deployment and ongoing monitoring. Stakeholders interacting with a given tool must understand enough about how the technology works to recognize problems. Users should be recruited to aid in continuous monitoring and refinement of tools. Resources must be devoted to upskilling all involved.

Institutional structures should include an organizational committee that articulates guiding principles. Multiple frameworks are arising from various leadership organizations. Local teams should review, clarify, and publicize their institutional process. Resources must be put in place to support ongoing evaluation of the performance of these tools. Institutional assets, such as safe AI playgrounds or enterprise-sanctioned generative pre-trained transformers (GPTs), can support experimentation while protecting intellectual property, health information, and learner data. Training, to include foundational knowledge coupled with active application experiences such as prompt-a-thons and red-teaming exercises, is essential for all involved in the use of these tools.

Conclusion

Educational projects leveraging artificial intelligence and learning analytics demand a multi-disciplinary strategy, bridging educational and technical expertise. Although the specific capabilities of these technologies are rapidly evolving, educators can apply this framework to address key considerations with team members embarking on any technology-enabled project. A deliberate and informed approach — addressing problem definition, affordances of technology, data considerations, limitations of technologies, costs, implementation science, and responsible deployment — will position educators to deploy such tools responsibly, to the optimal benefit of learners at all levels and the patients they serve.

Useful resources

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