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Calibration Before Confidence in Pharmacy Education: Teaching Students to Recognize Uncertainty, Verify Drug Information, and Escalate Unsafe Decisions

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ABSTRACT

Pharmacy education routinely asks learners to become confident decision-makers, yet confidence alone provides little information about whether a decision is defensible. A learner may be confident and correct, confident and wrong, uncertain despite adequate competence, or appropriately hesitant because the available information is incomplete or the consequences of error are substantial. Educationally useful confidence therefore depends on calibration: the correspondence between a learner's confidence judgment and demonstrated performance. Knowledge, reasoning, verification, and supervision provide complementary evidence about whether independent action is justified. This Commentary examines calibrated confidence as a set of separable educational competencies. It distinguishes recognition of uncertainty from tolerance of uncertainty, verification from information retrieval, and escalation from generalized lack of confidence. It further argues that the appropriate response to uncertainty changes with the nature of the information problem and the consequences of an incorrect decision. Learners should be able to identify what remains unknown, select an appropriate source or verification strategy, explain the limits of the resulting evidence, and determine whether independent action remains defensible. Assessment should therefore sample more than confidence or final-answer accuracy. Cases, observed clinical encounters, source-retrieval tasks, reasoning explanations, reflective calibration, and supervision judgments can provide complementary evidence about different parts of the decision process. The educational objective is neither maximal confidence nor habitual caution, but appropriately supported independence.

Keywords: Pharmacy education, Metacognition, Clinical uncertainty, Drug information, Clinical reasoning, Entrustment

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Introduction

Confidence is often treated as a desirable consequence of professional education, yet its educational meaning depends on what the learner can actually do. A learner who is appropriately confident after accurate reasoning occupies a different state from one who expresses the same confidence while overlooking a contraindication, misreading a source, or failing to recognize missing information. Conversely, hesitation does not necessarily indicate inadequate preparation; it may represent appropriate sensitivity to ambiguity, unfamiliarity, conflicting evidence, or the potential consequences of error. Conceptual work on confidence–competence alignment therefore places the relationship between judgment and capability at the center of interpretation, while reviews of health-

professions education show why self-reported confidence should not substitute for objective evidence of competence [1, 2]. Pharmacy education needs this distinction because professional practice requires learners to decide not only what they think is correct, but also when their current basis for acting is sufficient.

Uncertainty adds another layer. It includes more than a feeling of discomfort. Healthcare uncertainty has been conceptualized as a set of cognitive, emotional, and behavioral responses that follow recognition of incomplete knowledge or information [3]. A learner may know that a fact has not been learned, may encounter conflicting studies, may be unsure whether a source applies to a particular patient, or may recognize that a seemingly clear recommendation carries unusually serious consequences if wrong. These situations can produce similar expressions—"I am not sure"—while requiring different educational responses. Treating them as one generalized deficit makes it difficult to determine whether the learner needs knowledge, additional evidence, better appraisal, contextual reasoning, consultation, or supervision.

Drug-information education illustrates the practical importance of separating these responses. A systematic review of North American pharmacy education found substantial scholarship on literature evaluation and foundational drug-information instruction, with less emphasis in the published literature on searching, systematic response development, and formative assessment [4]. These are consequential differences. A learner who can critique a trial may still select an unsuitable source for a dosing question; another may retrieve an authoritative source but fail to identify a population mismatch; another may find conflicting evidence yet act as if disagreement has been resolved. Verification is therefore broader than remembering where to search. It is the disciplined process of determining what information is needed, selecting evidence capable of answering that question, examining the reliability and applicability of the information obtained, and deciding whether residual uncertainty changes what may safely be done.

Pharmacy education already possesses structures that can support this interpretation without inventing an additional hierarchy of competence. The 2022 Curricular Outcomes and Entrustable Professional Activities for pharmacy graduates connect educational outcomes with observable professional activities and the degree of responsibility learners are expected eventually to assume [5]. The unresolved educational problem is how students learn to recognize the point at which uncertainty, verification failure, or decision consequence should alter that responsibility. This Commentary therefore treats uncertainty recognition, source verification, metacognitive calibration, consequence sensitivity, supervision, and escalation as distinguishable competencies that should be taught together but assessed with evidence appropriate to each.

Calibration as a relationship between judgment and performance

Calibration concerns correspondence between a learner's judgment and what the available evidence about performance justifies. In educational practice, that requires more than asking, "How confident are you?" Metacognition includes knowledge about cognition, monitoring of one's current understanding and performance, and control over subsequent learning or action. Pharmacy educators can assess these processes differently—for example through judgments made before or after performance, comparisons between predictions and observed outcomes, explanations of reasoning, and decisions about whether further learning or verification is required [6]. A confidence score is therefore one possible observation within a larger metacognitive process.

Pharmacy-specific evidence suggests that these processes can be made more explicit. Metacognitive prompting in undergraduate pharmacy education has been used to elicit students' self-regulatory strategies, including planning and self-reflection, and higher-quality strategies were associated with stronger academic achievement [7]. Such findings do not establish that reflection alone creates safer clinicians. They do, however, support an important educational principle: learners can be asked to reveal how they reached a judgment, what information they considered sufficient, and what action they would take if their current understanding proved inadequate. Calibration becomes assessable when a judgment is connected to a task and to subsequent behavior.

Feedback is particularly relevant because calibration is modifiable. In a randomized study of medical interns interpreting chest radiographs, performance and information feedback improved measured confidence–accuracy calibration compared with no feedback [8]. Transfer to pharmacy decisions cannot be assumed, and the study could not reduce improved calibration to a single mechanism. Nevertheless, it demonstrates that confidence–performance correspondence is not merely a stable personality characteristic. Educational environments can influence how learners update judgments about what they know and how accurately they are performing.

This distinction also prevents overconfidence from becoming the only concern. Underconfidence may lead a capable learner to avoid appropriate responsibility, seek unnecessary confirmation, or fail to progress toward

independent practice. Overconfidence may lead another learner to stop searching too early or to act despite unresolved problems. Both states become educationally important when they alter behavior relative to demonstrated capability [1]. The instructional target is therefore appropriately supported action: a learner should become more willing to act independently when performance, evidence, and context justify independence, and more willing to verify or seek supervision when they do not.

Recognizing the kind of uncertainty

Before learners can respond appropriately to uncertainty, they must recognize what kind of problem they are facing. Evidence on uncertainty tolerance cautions against treating uncertainty as a single stable learner attribute. Across healthcare studies, relationships between uncertainty tolerance and psychological, educational, and behavioral outcomes have been heterogeneous [9]. Some associations are more consistent than others, and differences in populations, measures, and contexts complicate attempts to interpret a learner globally as "good" or "poor" at uncertainty.

Measurement limitations reinforce that caution. Meta-analysis of commonly used uncertainty-tolerance scales found variation in reliability across instruments and populations, including lower aggregated internal consistency among medical students than physicians. A subsequent validity review identified important gaps, particularly for response-process evidence and consequences of testing [10, 11]. These instruments can remain useful for research and educational inquiry, but their scores do not justify a supervision decision by themselves. A learner should not be permitted or prevented from acting independently because an uncertainty-tolerance scale crosses an invented threshold.

Educational interventions also affect different aspects of uncertainty differently. A scoping review of interventions for medical students found changes across cognitive, behavioral, and emotional responses, while some interventions produced improvement in one domain alongside less favorable responses in another [12]. Increased comfort with ambiguity, for example, does not necessarily establish better source verification. Greater willingness to make a decision does not demonstrate that the decision is better reasoned. Reduced anxiety likewise cannot establish that a learner knows when consultation is warranted.

For pharmacy education, a more useful starting point is to identify the informational state confronting the learner. A knowledge gap exists when the learner recognizes that required knowledge is absent or insufficiently retrievable from memory. Unresolved evidentiary uncertainty exists when available information is incomplete, conflicting, methodologically limited, or only indirectly applicable. Misinformation or unreliable information creates a different problem because the learner may possess an answer that appears definite but lacks an adequate evidentiary basis. High-stakes ambiguity arises when remaining uncertainty becomes especially consequential because the plausible downside of error is large, irreversible, or difficult for the learner to detect and correct. These categories are an educational synthesis rather than validated diagnostic labels, and they may overlap in authentic practice. Their value lies in prompting different next actions instead of converting every expression of uncertainty into the same educational response.

A recognized knowledge gap may be resolved through an appropriate authoritative source. Conflicting evidence may require comparison of primary studies, guidelines, or specialist interpretation. Suspected misinformation requires corroboration before it is incorporated into reasoning. High-stakes ambiguity may remain unacceptable even after reasonable verification, making consultation or escalation appropriate. Recognizing uncertainty is therefore not an endpoint. It is the first decision about what additional evidence, reasoning, or supervision is required.

Verification as source-and-question matching

Verification is frequently described as checking information, but this formulation is too weak for pharmacy education. The learner must first identify the question precisely enough to determine what kind of source can answer it. Drug selection, interaction assessment, compatibility, dose adjustment, adverse-effect causality, pregnancy risk, or interpretation of emerging evidence may require different evidentiary routes. Verification also requires recognizing when a source provides general information but does not resolve the patient-specific question being asked.

Longitudinal pharmacy instruction offers evidence that repeated application matters. In one pharmacy curriculum, students who participated in progressive journal-club and case-based activities showed improved performance applying literature to patient cases [13]. The study cannot establish a universal curriculum or demonstrate

downstream patient-safety benefit, but it supports moving beyond isolated appraisal exercises. Verification becomes clinically meaningful when learners must use evidence to defend a decision for a particular patient and explain where that evidence ceases to apply.

The quality of appraisal can also be influenced by information learners bring to the task. In a randomized pharmacy-education study examining confirmation bias, prior beliefs about products mildly influenced assessment and recommendations, although study quality had a stronger effect [14]. This is a useful boundary condition. Learners should not be portrayed as incapable of objective appraisal, yet educators should teach them to ask whether familiarity, expectations, product reputation, or an initially preferred answer has narrowed the search for disconfirming information. Verification includes scrutiny of the reasoning process as well as the source.

Learner perception provides another incomplete signal. Pharmacy students evaluating drug-information training have reported generally favorable views of curricular preparation while also identifying mismatches between what they learned and what they encountered in experiential settings [15]. Positive perceived preparedness can therefore coexist with uncertainty about transfer to practice. A curriculum that intends to teach verification should assess source selection and information use in contexts that resemble the decisions learners will actually face.

Generative artificial intelligence provides a contemporary stress test of the same principle, although it is not the organizing subject of this Commentary. One 2024 evaluation of ChatGPT responses to medication-related questions found substantial problems with completeness, accuracy, directness, and fabricated references. Another evaluation of ChatGPT-4 on selected community-pharmacy tasks reported satisfactory performance in several areas while emphasizing the need for broader validation and attention to privacy and implementation limitations [16, 17]. The apparent contradiction is educationally useful. Fluency does not reveal reliability, but neither does the existence of one poor benchmark prove that every generated answer is unusable. Verification requirements depend on the tool, the question, the evidence available for corroboration, and the consequences of accepting an incorrect response.

Evidence specifically addressing artificial intelligence in pharmacy education was still limited within the 2017–2024 evidence window considered here. A 2024 scoping review identified only a small body of published work and highlighted limitations involving outcome evidence, generalizability, expertise, and ethical or legal considerations [18]. AI therefore belongs here as one example of why source credibility cannot be inferred from presentation quality. The broader competency remains source-and-question matching: learners should be able to explain why a chosen source is capable of resolving a particular question, what corroboration is required, and what uncertainty remains after the search is complete.

Verification should consequently end with a decision, not merely a citation. The learner must determine whether the retrieved evidence is adequate for independent action. Sometimes verification converts uncertainty into a defensible answer. Sometimes it reveals that the evidence is contradictory, patient-specific information is missing, or the question exceeds the learner's competence. In those cases, continuing to search indefinitely can be as problematic as stopping prematurely. The next competency is deciding when remaining uncertainty changes the required level of supervision.

Escalation as consequence-sensitive supervision

Escalation becomes educationally meaningful when it is linked to observable reasoning rather than generalized nervousness. Analysis of expert feedback on student-pharmacist clinical reasoning identified recurring standards involving accuracy, concision, specificity, thoroughness, and connectedness [19]. These standards are not an exhaustive definition of competent reasoning, and they do not specify escalation thresholds. They nevertheless demonstrate that reasoning quality can be made visible through features more informative than a final answer alone. An apparently correct recommendation may rest on missing connections or incomplete consideration of relevant information; an incorrect recommendation may arise from a remediable knowledge gap rather than a broader inability to reason.

Structured teaching can strengthen these processes. In third-year student pharmacists, a cognitive-apprenticeship approach was associated with improvements in clinical-case performance and perceived preparedness over a 15-week course [20]. Because the study was not randomized, improvement cannot be attributed solely to the educational model. Its relevance is narrower: clinical reasoning can be taught through modeling, guided practice, feedback, and progressive responsibility rather than expected to emerge automatically from accumulated factual knowledge.

Feedback itself need not originate from one source. Comparisons of peer and resident teaching-assistant feedback on student-pharmacist clinical reasoning found differences across feedback-quality dimensions rather than uniform superiority of one group [21]. Multiple observers may therefore expose different aspects of the reasoning process. This matters for escalation because a single successful performance does not establish that a learner can reliably recognize when a future case exceeds independent capability.

Entrustable professional activities provide a useful language for this transition. EPAs connect competencies to units of professional work and to the supervision required before responsibility is entrusted [22]. For the present problem, the important educational question is not whether the learner feels confident enough to act, but whether the learner can justify the degree of independence being taken. Escalation is one possible expression of that judgment. It may involve asking a preceptor to confirm a source interpretation, consulting a pharmacist with specialized expertise, requesting missing patient information, or transferring decision authority when unresolved uncertainty exceeds what the learner can responsibly manage.

Pharmacy-specific work on entrustment-supervision scales shows why this decision cannot be reduced to a fixed numerical cutoff. Expert stakeholders considering supervision assessment identified issues including granularity, differences between learners and licensed practitioners, repeated use over time, and the handling of problematic professional behavior [23]. Subsequent analysis of available supervision scales has likewise emphasized differences in prospective versus retrospective framing and in how levels of supervision are described [24]. These are reminders that entrustment is contextual. The same unresolved uncertainty may be manageable independently for an experienced practitioner and require consultation for a learner, while the same learner may appropriately act independently in a familiar low-consequence problem but escalate a superficially similar decision when the potential harm of error is greater.

The article therefore treats escalation as consequence-sensitive supervision. This is not a competence ladder and does not assign numerical boundaries between independence and supervision. Instead, the decision to act, verify further, consult, or escalate depends on three interacting questions: how well the learner's judgment is calibrated to demonstrated performance; whether verification has sufficiently reduced the relevant uncertainty; and what would follow if the remaining judgment were wrong. High consequence does not automatically prohibit independent action, and uncertainty does not automatically require escalation. The combination becomes concerning when the learner cannot defend the informational basis for action or cannot reliably manage the consequences of being mistaken.

This relationship also creates an assessable educational task. A learner can be presented with a case and asked not only for a therapeutic decision, but also to identify what remains uncertain, select and justify verification sources, state what evidence would change the recommendation, and indicate the point at which consultation becomes necessary. The observable outcome is then the appropriateness of the decision process, not simply whether confidence is high or low.

The distinctions developed across uncertainty recognition, verification, reasoning, and supervision can be compressed into an educational competency map. **Table 1** links different informational problems with the learner behavior, verification strategy, escalation trigger, and performance evidence that would make the response assessable.

Table 1. Educational responses to uncertainty according to verification need, consequence, and supervision requirement

Informational state encountered by the learner	Observable learner behavior expected	Verification target	Condition prompting consultation or escalation	Performance evidence an assessor can observe
Recognized knowledge gap	States what is unknown before acting; identifies the specific information required	Appropriate authoritative drug-information source or directly relevant evidence	Required information cannot be established within the learner's available resources, time, or competence	Accurate formulation of the question; appropriate source selection; correct use of retrieved information

Unresolved or conflicting evidence	Identifies disagreement, methodological limitation, or applicability problem instead of selecting the most convenient answer	Comparison of relevant guidelines, primary evidence, patient-specific factors, or expert interpretation	Material disagreement remains unresolved and could alter a consequential therapeutic decision	Explanation of competing evidence; appraisal of applicability; identification of information that would change the decision
Suspected misinformation or unreliable information	Withholds acceptance until the claim is corroborated; checks provenance and consistency	Independent authoritative or primary source capable of confirming the claim	The claim cannot be verified adequately or would create unacceptable risk if wrong	Detection of unsupported claims; corroboration strategy; justified rejection or qualified use of the information
Contextual patient-specific uncertainty	Identifies why general evidence may not apply directly to the individual case	Patient-specific data plus evidence relevant to the modifying factor	Missing or ambiguous patient information prevents a defensible application of general evidence	Recognition of applicability limits; targeted information request; conditional recommendation
High-stakes ambiguity	Explicitly considers the consequence of error while evaluating remaining uncertainty	Highest-relevance evidence available plus supervisory or specialist input where appropriate	Residual uncertainty remains material and the learner cannot adequately prevent, detect, or manage the potential harm of an incorrect decision	Appropriate change in level of independence; explanation of why consultation is warranted; avoidance of unsupported certainty

Note. The informational states and response mappings are a proposed educational synthesis of the evidence reviewed in the source sections. They are not validated competency thresholds and are not intended to assign fixed levels of supervision.

Calibration and consequence also interact dynamically. As potential harm increases, the evidentiary basis required for independent action should become more demanding; better calibration does not remove the need for verification when information itself is unreliable. **Figure 1** represents these relationships without converting them into a numerical competence scale.

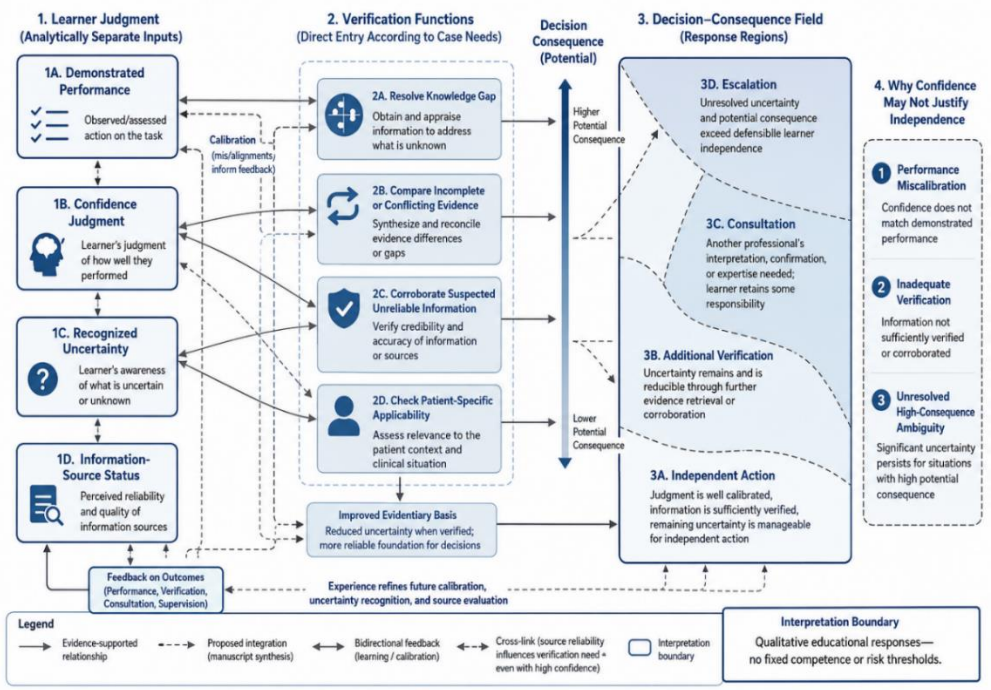

Figure 1. Calibration and consequence jointly constrain independent pharmacy decisions

Assessing the decision process

Assessment should determine what a learner's performance actually establishes. Objective structured clinical examinations are already widely used across US pharmacy programs, including for progression and other consequential decisions, but their implementation, structure, and stakes vary substantially [25]. An OSCE can show whether a learner performs observable actions under standardized conditions. It does not automatically reveal whether confidence was appropriately calibrated, why a particular source was trusted, what uncertainty the learner recognized, or whether the learner would have sought help if the case changed.

EPA-aligned OSCEs illustrate both the potential and the limits of observed-performance assessment. In one pharmacy curriculum, stations aligned with entrustable professional activities allowed learners to demonstrate several practice competencies, yet ratings differed among evaluator types in some stations [26]. Such variation does not invalidate OSCEs. It demonstrates why a single observed score should not be expected to carry every inference required for progression toward independence. The evidentiary question is narrower: what did this particular assessment make observable?

The same principle applies to confidence judgments. Self-assessment evidence shows that perceived competence should not be treated as interchangeable with demonstrated competence [2]. A confidence rating can nevertheless contribute useful information when paired with performance. Correct performance accompanied by very low confidence differs educationally from equally correct performance accompanied by calibrated confidence; an incorrect answer accompanied by high confidence differs from an incorrect answer accompanied by recognition that additional verification is necessary. Calibration requires the relationship between those observations rather than either one in isolation.

Assessment of metacognition also depends on matching method to construct. Prediction of performance, post-task confidence, explanations of knowledge limitations, and decisions to seek additional information reveal different aspects of monitoring and control [6]. Similarly, clinical-reasoning assessments can examine whether a recommendation is accurate, specific, sufficiently connected to patient information, and supported by defensible reasoning [19]. Feedback studies further suggest that different observers may identify different useful features of that reasoning [21]. No single format therefore needs to perform every assessment function.

For this Commentary, the central assessment principle is inferential separation. If educators want evidence that a learner can retrieve information, they should observe retrieval. If they want evidence of verification, the learner should justify source selection and corroboration. If they want evidence of calibration, judgment should be compared with performance. If they want evidence of escalation behavior, cases must contain situations in which continued independent action, further verification, consultation, and transfer of responsibility are meaningfully distinguishable. Combining these observations may eventually support an entrustment judgment, but the component evidence should remain visible rather than being hidden inside one global confidence or competence score.

The principal assessment formats therefore differ in what they can defensibly establish. **Table 2** compares their most relevant inferential roles for calibrated pharmacy decision-making.

Table 2. Assessment methods and the aspects of calibrated pharmacy decision-making they can establish

Assessment method	What the learner must make observable	Strongest inference supported	Important inference it cannot establish alone	Useful calibration or escalation feature
Patient case or case series	Therapeutic reasoning, identification of missing information, interpretation of evidence	Quality and consistency of applied reasoning across controlled scenarios	Actual workplace independence or response under real-time supervision	Require the learner to state what would trigger additional verification or consultation
OSCE	Observable clinical actions, communication, information gathering, and decisions under standardized conditions	Performance of specified professional tasks in a controlled encounter	Stable calibration across different contexts or authentic workplace entrustment	Add explicit points where the learner may act, verify, consult, or escalate

Oral defense or structured reasoning explanation	Assumptions, evidence links, uncertainty recognition, and justification of a recommendation	Whether the learner can defend the reasoning underlying a decision	Consistent execution of that reasoning in practice	Ask what evidence would change the decision and why
Drug-information retrieval task	Search formulation, source selection, corroboration, and application	Ability to locate and verify information appropriate to a defined question	Broad clinical competence or appropriate independence in unrelated tasks	Include incomplete, conflicting, or unreliable information requiring verification choices
Reflective calibration task	Prediction or confidence judgment compared with subsequent performance and planned response	Relationship between perceived certainty and demonstrated performance	Clinical competence without independent objective performance evidence	Examine whether feedback changes later confidence, verification, or help-seeking decisions

Note. The assessment functions are an evidence-informed synthesis rather than a ranking of assessment methods. Individual programs may combine several functions within one assessment. No format should be interpreted as a validated stand-alone threshold for independent practice.

Educational implications

Pharmacy curricula can teach these competencies separately without fragmenting clinical reasoning. Early instruction can make the distinctions explicit: recognizing that information is missing is different from finding it; finding a source is different from verifying that it answers the patient-specific question; reaching an answer is different from knowing how strongly that answer is supported; and being capable of acting is different from deciding that independent action is appropriate. Published drug-information education already provides a foundation for literature evaluation and evidence application [4]. The additional educational task is to make the learner's response to unresolved uncertainty visible.

Cases should therefore include decisions in which the correct educational endpoint is not always immediate independent action. Learners can be asked to identify what they know, specify what remains uncertain, choose a verification strategy, explain how the resulting information changes the recommendation, and state when another professional should become involved. Entrustment provides an existing professional rationale for connecting these decisions to supervision [22]. The purpose is not to reward frequent escalation. Unnecessary escalation can indicate weak knowledge, inefficient verification, or underconfidence just as failure to escalate may reveal overconfidence or inadequate consequence sensitivity.

Feedback should likewise address the relationship between judgment and outcome. When learners are correct, educators can examine whether the reasoning and confidence supporting the answer were also appropriate. When they are wrong, feedback can distinguish a factual knowledge gap from flawed verification, misapplication of evidence, failure to recognize uncertainty, or an unjustified decision to proceed independently. Evidence that feedback can alter measured calibration supports treating this relationship as teachable rather than fixed [8].

High-stakes assessment requires particular caution. Existing validity evidence does not support converting uncertainty-tolerance scores into supervision thresholds [11], and widespread OSCE use does not mean that one station or composite score captures every component of calibrated decision-making. Programs should instead determine which observations are necessary for the inference they intend to make. The higher the consequence of the educational decision—for example, progression toward less supervised patient care—the stronger the rationale for combining performance, reasoning, verification, and supervision evidence.

These propositions are testable. Future pharmacy-education studies could compare otherwise similar learners receiving standard case instruction with learners required explicitly to justify whether they would act, verify, consult, or escalate. The relevant outcome would not be increased or decreased confidence by itself. More informative outcomes would include correspondence between confidence and objective performance, appropriateness of source selection, recognition of unresolved uncertainty, quality of reasoning, and independently adjudicated appropriateness of supervision decisions. A stronger test would determine whether these measures provide useful information beyond conventional knowledge or performance scores. If they do not, the additional educational complexity would require reconsideration.

Conclusion

Pharmacy students need confidence sufficient to act, uncertainty sensitivity sufficient to recognize when an answer is not yet defensible, verification skills sufficient to improve the evidentiary basis of decisions, and professional judgment sufficient to seek supervision when consequences exceed what they can responsibly manage. These abilities are related but not interchangeable. Calibrated confidence reflects correspondence between subjective certainty and demonstrated performance; it contributes to, but does not alone establish, appropriately supported independence. Pharmacy education can make that independence more defensible by assessing how learners recognize uncertainty, verify information, interpret the consequences of error, and decide when responsibility should remain with them or move to someone better positioned to act.

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