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PERSPECTIVE

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Fostering an "investigating mindset": Why is it important in digital forensic science education?

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Abstract

The importance of the field of digital forensics (DF) is growing, where digital evidence is increasingly recognized as a crucial part of many investigations. As a result, criminal justice systems rely on DF practitioners to conduct robust investigations of digital devices and their data, and interpret and present these results in a way that can be relied upon. Undertaking this task appropriately requires a practitioner to have a range of skills; however, focus is often placed on the need for and importance of technical competency. Technical skills are vital in this role, that cannot be in dispute; however, this work discusses the need for practitioners to also have an "investigative mindset."

This article is categorized under:

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KEYWORDS

digital forensics, digital investigation, investigative mindset

1 | INTRODUCTION

There is a notable trend among people committing crime to quickly embrace technology for their illicit activities (Europol, 2017). This is exacerbated by the fact that almost all aspects of contemporary life have been digitized, leading to criminals becoming "digital natives" (Europol, 2021, p. 15). Consequently, law enforcement agencies are now often facing investigations with digital components (Home Office, 2016; Science and Technology Select Committee, 2019). Due to the diversification of technology and criminal investigations, the spectrum of cases requiring digital forensic (DF) analysis is highly diverse, ranging from common devices like smartphones and computers, to more niche equipment such as alarm systems (Hutchinson et al., 2023), vehicles (Le-Khac et al., 2020), and industrial machinery (Interpol, 2023). However, the multifaceted nature of technology, its potential for misuse, and the complexity of digital investigations (HM Inspectorate of Constabulary and Fire & Rescue Services, 2022) means that it is unrealistic for any single individual to be an expert in all areas (Horsman & Shavers, 2022). Adding to this are the overwhelming amount of materials that need to be analyzed, and ethical considerations to be upheld. When required, these tasks are conducted by practitioners in the DF field, or by those that have been trained to use appropriate forensic techniques.

It is argued here that addressing the aforementioned challenges requires not only technical proficiency but also methodological efficiency (here-after referred to as the "investigative mindset"). It is also the opinion of the authors that

this involves a transformation in training from solely teaching techniques to embracing a comprehensive curriculum that imparts forensic science principles. The present opinion piece will develop this idea by pondering on the following four questions: (1) Is training solely linked to technical methodologies sufficient, or should it encompass an investigative facet as well? (2) Why does the discourse tend to overshadow the investigative aspects of the DF process in favor of the technical dimension? (3) How is the investigative mindset precisely defined? (4) What strategies can be employed to effectively cultivate and train the investigative mindset?

1.1 | Question 1: Should training encompass an investigative mindset?

Technical skills are pivotal to any DF practitioner and their organization, and this work seeks to first stress this point. Without knowledge of the technology types in existence, and the tools and techniques needed to investigate them, very little progress can be made in this domain and the field quickly becomes unfit for its purpose of supporting law enforcement and criminal justice systems to understand and police crime (Broucek & Turner, 2006). It is, therefore, understandable why technical skills are prioritized during training. However, the primary objective of forensic science in studying traces is to understand "anomalous events of public interests" (Roux et al., 2022). This overarching aim necessitates that an effective practitioner must have more than just technical attributes (Boddington, 2016). Understanding past events of interest, whether achieved through crime attribution, chronological sequencing, or sub-event identification, arguably demands an investigative mindset.

We seek at this point to add a point of clarification. While we may consider differentiating the role of investigators and analysts from that of DF practitioners, we argue that all DF practitioners are investigators by virtue of the work they are required to conduct. While DF practitioners are those primarily tasked with interacting with and understanding device content, to do this thoroughly and effectively requires an investigative mindset.

The argument in favor of a more holistic approach gains momentum when considering several factors. To start, the landscape of technology is marked by its rapid evolution and expanding diversity, leading even seasoned experts to frequently confront novel challenges. Those operating in the field of DF must first have had formal training, and given the changing nature of technology, continuously seek to develop their skills and knowledge (National Police Chiefs' Council, 2020). It becomes then not only valuable but imperative for DF specialists to possess the capacity to independently acquire new technical knowledge and validate new techniques. Neglecting to teach a methodology to adapt to new encounters could potentially result in a significant oversight. Second, triage and selective device and data extractions are increasing in importance in the face of increasing data volumes and the number of devices being seized and requiring examination (Horsman, 2022). The questions that require addressing through DF examinations are growing in complexity. DF investigations are no longer restricted to a linear process involving acquisition, analysis, and report, where the maximum amount of device data is sought for review in all cases using all-encompassing search and parse tools that cast the "digital net" far and wide in an effort to establish "evidence." The pursuit of maximal device data for comprehensive review must be supplanted by a more strategic approach, which results in a greater diversity of decisions to be made by the examiner and a greater recognition of the impacts and implications of poor decision-making and processing. Third, tensions between DF and privacy mean there is now a need for compromise (Casey, 2019), with more strategic and targeted approaches preferred, limiting collateral intrusion. Finally, an increasing emphasis is being placed on recognizing the inherent uncertainty associated with digital trace information and the subjectivity that can impact an expert's work when presenting a forensic report. It is becoming more widely accepted that the outcomes of a DF analysis are more akin to scientific opinions rather than purely factual reports.

In 2022, the HM Inspectorate of Constabulary and Fire and Rescue Services (2022) noted that DF staff "lacked knowledge and experience in the management of investigations" which led to "a flawed decision-making process on what investigations to prioritize." Conducting effective DF casework relies not just on a practitioner's ability to operate and deploy forensic tools, but their understanding of the requirements of the investigation. This can also mean understanding how information and resources beyond a DF examination can also play an important role—many investigations are a collaborative process. This resonates with the broader scope of forensic science, covering the study of traces through detection, recognition, collection, examination, and interpretation. Baechler et al. (2020) proposed a continuous model depicting forensic science's role in case resolution and question answering (shown in Figure 1). A connection between the investigative mindset and forensic science is evident in the comparison of Rossy's model (Ribaux, 2014) with Bull and Blandón-Gitlin's (2019) three investigation components. Rossy's

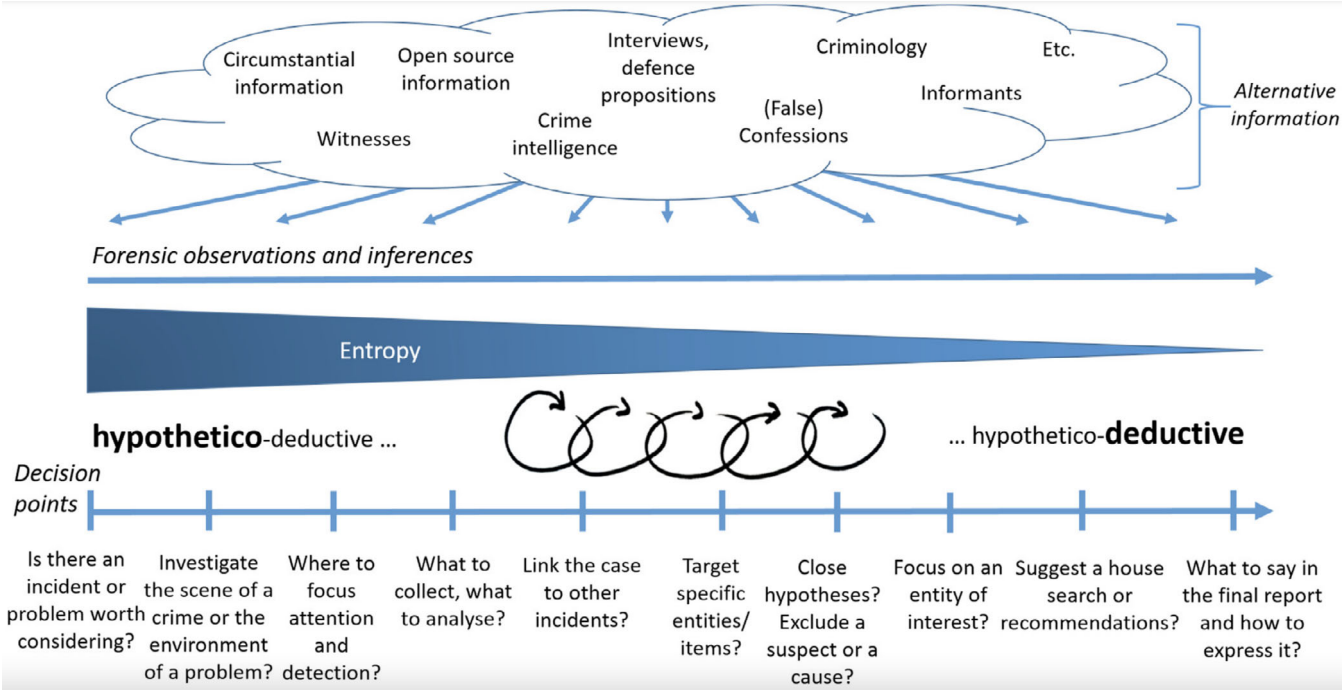

FIGURE 1 Baechler et al.'s depiction of the forensic role (2020).

model illustrates an iterative cycle starting with the event of interest, involving information structuring and hypothesis formulation, while Bull and Blandón-Gitlin's (2019) components include "information retrieval," "inference drawing," and "decision making."

In the context of DF, technical skills facilitate information retrieval, but the approach should be grounded in logical investigative practices to fulfill inquiry requirements, rather than generic and nondiscriminatory data-gathering. As Lee (2017) underlines, investigators are guided by preliminary theories or hypotheses in their quest for evidence. The adept generation and examination of competing hypotheses is an essential facet of effective investigations, shielding them from biases, flawed thinking, and the peril of tunnel vision (Elaad, 2022; National Centre for Policing Excellence, 2005; Renaud et al., 2021; Sunde & Dror, 2019). Having an investigative mindset can remind practitioners that their role is to try and establish a reasonable interpretation of the meaning of any data that they are tasked to examine, considering both inculpatory and exculpatory lines of inquiry.

The investigative mindset can bring robust logic, objectivity, and justifiable strategic approaches to the investigative process, directing how forensic techniques should be deployed and helping practitioners to effectively address the "whos, whats, whys, wheres, whens, and hows" that arise in any given case (Shavers, 2023). It may also be necessary to distinguish the investigative mindset from that of critical thinking skills. We suggest that critical thinking applies to the technical analysis of data to make informed decisions based on the validity and relevance of the data to form reasoned conclusions. Critical thinking skills may be taught in DF programs without specifically being stated as such, yet formal teachings relating to the investigative mindset in DF appear lacking.

Investigation quality is largely dependent on the investigator's ability to "make sense of incoming information, to generate all adequate investigative hypotheses, and to identify appropriate investigative actions" (Fahsing & Ask, 2016, p. 203). It has been suggested that the investigative mindset is made up of five principles—"understanding the source of material," "planning and preparation," "examination," "recording and collation," and "evaluation" (National Centre for Policing Excellence, 2005). Applying these principles during the process of forming investigative hypotheses and evaluating them helps to ensure any decisions made are appropriate and defensible, and value of any digital evidence is understood (Horsman, 2021). Neglecting to teach the investigative mindset's principles and failing to train this competence before operational deployment might lead to missed digital opportunities and compromised investigations (Palmer, 2018), as well as potential unreasonable practices in the future.

1.2 | Question 2: Why does the discourse tend to overshadow the investigative aspects of the DF process in favor of the technical dimension?

There is a gap in understanding how practitioners actually approach strategic and decision-making aspects of the investigative process (Horsman, 2019), with maybe an underlying assumption that individuals possess an inherent investigative mindset and can seamlessly integrate into a crime investigation environment. The opposite is however suggested by the observed contrast in how crime scene investigators handle scenes of interest and the different decision-making approaches exhibited by those with different backgrounds (law enforcement, forensic science degree, number of years of experience, and type of training) (Hazard, 2014).

The challenge in explicitly highlighting the need for an investigative mindset could stem from the fact that references to it might be concealed under terms like problem-solving, critical thinking, and strategic decision-making. When considering DF training and education, the focus often gravitates toward tool-based materials and understanding system functionalities. Subject to the limitations of their study, McCullough et al.'s (2021) review of DF programs in the United States suggests that the investigative mindset may not be consistently formally acknowledged or taught as part of syllabuses, and potentially further afield. Tu et al. (2012) curriculum proposal focuses on technical and courtroom skills, and the Sans (2023) guidance on how to become a DF analyst focuses mainly on the gathering of skills at a technical level. Naqvi et al. (2019) also note that DF education often spawns from the principles of computer science and argue that students also require investigative skills.

In various job advertisements, the requirement for an investigative mindset is sometimes stipulated, but the actual meaning of this term might not be widely understood. For instance, Suffolk Constabulary's (2021) job advert explicitly demands an "ability to demonstrate an investigative mindset" for a trainee mobile device examiner role. Similarly, positions from Morgan McKinley (Efinancialcareers, 2023) and Johnson Controls (2023) acknowledge this aspect, yet without providing a clear definition. On the academic side, the UK Cyber Security Council (2023) references "problem solving" and "logical thinking" as required skills. Hranický et al. (2021) work to develop a skillsmap in the incident response arena has highlighted critical thinking as an important non-technical skill and Salt et al. (2011) provide emphasis on "investigative skills rather than investigative tools" in their curriculum. Sachowski's (2019) educational roadmap highlights critical thinking and analytical skills as important facets of the practitioner. The College of Policing's (2023) role profile for DF practitioners requires those in it to provide "investigative assistance," "support the investigative strategy," "guide the investigation on the best course of action in the circumstances," have "knowledge of technology and forensic science principles," and are able to "separate information and decide whether it is irrelevant or relevant and its importance," but no explicit reference to the investigative mindset.

This lack of shared comprehension suggests that the concept of an investigative mindset may not be universally recognized. The challenge may then stem from a potential lack of clear understanding and concise definition of the investigative mindset. This can result in vague descriptors that inadvertently imply that organizations are seeking this skill without precisely articulating its nature.

1.3 | Question 3: How is the investigative mindset precisely defined—Does it possess a formal, explicit definition?

The concept of the investigative mindset is multifaceted, as various definitions emerge from the literature. The Australian Federal Police's characterization (Australian Federal Police, 2020) reflects an investigative mindset as inquisitive, objective, and adaptable, encouraging continual learning, critical thinking, and adaptive strategy development in response to evolving case knowledge. Similarly, Fahsing and Ask's perspective (Fahsing & Ask, 2016) underscores the capacity to comprehend incoming information, formulate comprehensive investigative hypotheses, and identify suitable investigative actions.

The College of Policing (2021) characterizes the investigative mindset as a "systematic approach to gathering and assessing material" that forms the foundation of effective investigations. Bird and Cheah (2014) liken it to "connecting pieces of the jigsaw puzzle." Both seem to imply a method for collecting and processing information for research purposes. The National Centre for Policing Excellence's (2005, p. 60) Core Investigative Doctrine suggests that "the application of an investigative mindset will bring some order to the way in which investigators examine material and make decisions." The National Centre for Policing Excellence (2005) further suggests that the investigative mindset is made

up of five principles—"understanding the source of material," "planning and preparation," "examination," "recording and collation," and "evaluation."

These five principles are also cited as key points of the investigative mindset by Cook et al. (2023). They define the investigative mindset as "A state of mind that an effective investigator needs to develop which assists with examining the material gathered throughout an investigation and on which decisions are made. It involves maintaining a professional curiosity, being receptive to other suggestions when approaching problem-solving and decision-making, keeping an open mind and looking for other explanations, and, not focusing on a single or small number of theories or hypotheses. Going beyond these general elements, applying an investigative mindset requires mental discipline and a structured approach. This involves understanding the material obtained by the investigation, planning how to obtain the material and approach its examination, how to record the examination, evaluate the results, and review them in the context of how they apply to the investigation and their priority."

While these definitions and concepts of the investigative mindset may have subtle differences, they share common elements such as a systematic approach to gathering and evaluating evidence, the importance of logical thinking, critical evaluation of multiple hypotheses, maintaining objectivity, and adapting strategies as the investigation progresses. A parallel with the processes and activities of forensic science as described in the Framework for Harmonizing Forensic Science Practices and Digital/Multimedia Evidence (Jaquet-Chiffelle et al., 2018) can then be drawn here. In this framework, forensic science is described as the systematic and coherent study of traces to address legal inquiries pertaining to authentication, identification, classification, reconstruction, and evaluation. The framework outlines forensic activities as encompassing survey, preservation, examination, documentation, analysis, integration, and interpretation. While some arguments can be made on the restrictive aspects of this definition of forensic science, it does however allow for connections with the five investigative questions and the five investigation principles previously introduced. This connection is more explicit in the third principle of the Sydney declaration on forensic science: "Forensic science is case-based and reliant on scientific knowledge, investigative methodology, and logical reasoning." (Roux et al., 2022). The description of this principle further highlights asking relevant questions, making observations, forming propositions (hypotheses), and testing those propositions as part of the forensic process.

The various definitions of the investigative mindset may slightly differ, however, they collectively underscore the importance of cultivating a disciplined and strategic approach to investigations. As the importance of the investigative mindset is already acknowledged within forensic science, its formal integration into the training of DF practitioners is imperative.

1.4 | Question 4: What strategies can be employed to effectively cultivate and train the investigative mindset?

It is impossible to equip practitioners with an all-encompassing package of information that can prepare them for everything they may encounter when operational. One approach to designing a DF curriculum is to tailor content according to prevailing technology trends, ensuring relevant and comprehensive skill sets. This approach, however, relies on practitioners bearing the responsibility of keeping their technical skills current (and being knowledgeable in how to do so), as previously addressed. While achieving mastery in all technical domains may be unfeasible, instilling fundamental principles of effective investigative decision-making, hypothesis generation, and evaluation is imperative for all students.

This raises two potential avenues: on-the-job training or prior academic instruction. The former permits novices to cultivate best practices during operational experiences. Peer-review of decisions and practices as well as the presence of support are crucial to ensure that practitioners are on a trajectory of effective development. It is imperative to prevent practitioners from entering the industry unprepared, thereby avoiding the unrealistic expectation that they should be capable of consistently making informed and rational decisions without the necessary training or guidance. The second option might appear somewhat more challenging to implement. Can the investigative mindset be effectively taught in the absence of exposure to actual cases?

A parallel can be drawn here between the investigative mindset required in the application of DF science and the process of medical diagnosis. Both domains require a methodical and rigorous approach to analyzing intricate information, generating and testing hypotheses systematically, interpreting results, and making well-informed decisions based on the available evidence. Exploring the training methods for future medical professionals and the existing frameworks for teaching diagnosis could provide valuable insights for teaching the investigative mindset to future DF practitioners.

Training in complex problem-solving tasks, like diagnosis, benefits from practical experience coupled with adequate prior knowledge (Kolodner, 1992; Vanlehn, 1996). Nevertheless, apart from on-the-job training, opportunities for real-life problem-solving are not always available. This limitation becomes particularly noticeable in situations that occur infrequently, involve temporal gaps between decisions and outcomes, or necessitate repetitive practice, particularly within domains characterized by health or social interactions (Chernikova et al., 2020). Moreover, even when opportunities exist, real-life practice might not always be the optimal choice. Ethical and security concerns, along with the potential cognitive and emotional burden on students and the intricacies of complex real-world scenarios, can make unguided real-life practice less viable and sub-optimal for learners (Grossman et al., 2009). Hence, simulations that replicate real-world scenarios to varying degrees can sometimes offer a more effective learning environment compared with solely increasing exposure to real-life situations (e.g., Stegmann et al., 2012). Varied forms of scaffolding (role-play, document, virtual object, virtualization) can effectively support simulation-based learning across diverse phases of knowledge and skill advancement (Chernikova et al., 2020). Heitzman et al. (2019) offer a conceptual framework illustrating different forms of scaffolding and factors to consider when cultivating diagnostic competences through simulation-based approaches.

Exposure to mock cases (Horsman & Lyle, 2021; Tu et al., 2012) is already a prevalent practice in DF training, education, and forensic science. For instance, Kummer et al. (2022) delve into the implementation of a comprehensive 140-h scenario-oriented practical course, employing both on-site and online interactions to foster practical, technical, and collaborative skills, alongside critical thinking, problem-solving, and investigative skills. Furthermore, within the United Kingdom, the College of Policing offers a range of courses specifically tailored, either wholly or partially, to the enhancement of investigation skills (Cook et al., 2023).

Considering these observations, the authors propose that despite the acknowledged challenges associated with teaching the investigative mindset, the endeavor is both feasible and already being practiced within conventional forensic science and policing education. Leveraging insights from established curriculum frameworks in these domains and drawing upon research findings related to the pedagogy of teaching diagnostic skills, presents a promising path for integrating and implementing the principles of the investigative mindset.

2 | FINAL THOUGHTS

Put simply, it is argued that a crucial and often overlooked skill that practitioners in the DF field need is the investigative mindset. Practitioners need it to be effective and hiring organizations want it if their workforce is to be effective. It is suggested that as a discipline we could increase our understanding of it and formalize it as a key competency for practitioners to have. Practitioners should be able to demonstrate it and that it is effective, however first, training and education providers must recognize its importance and ensure that those entering this field do so with it.

AUTHOR CONTRIBUTIONS

Graeme Horsman: Project administration (equal); writing – original draft (equal); writing – review and editing (equal). **Elenore Ryser:** Writing – original draft (equal); writing – review and editing (equal). **Brett Shavers:** Writing – review and editing (supporting).

CONFLICT OF INTEREST STATEMENT

No conflicts of interest to declare.

DATA AVAILABILITY STATEMENT

Data sharing not applicable – no new data generated.

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RELATED WIREs ARTICLES

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