A Case Study of Phishing Incident Response in an Educational Organisation

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Malicious communications aimed at tricking employees are a serious threat for organisations, necessitating the creation of procedures and policies for how to quickly respond to ongoing attacks. While automated measures provide some protection, they cannot completely protect an organisation. In this case study, we use interviews and observations to explore the processes staff at a large University use when handling reports of malicious communication, including how the help desk processes reports, who they escalate them to, and how teams who manage protections like the firewalls and mail relays use reports to improve defences. We found that the process and work patterns are a distributed cognitive process requiring multiple distinct teams with narrow system access, and tactic knowledge. Sudden large campaigns were found to overwhelm the help desk with reports, greatly impacting staff's workflow and hindering effective application of mitigation's and the potential for learning. We detail potential improvements to the current ticketing system, and reflect on ITIL, the framework of best practices that informed the full process.

CCS Concepts: • **Security and privacy** → *Phishing*; *Social aspects of security and privacy*.

Additional Key Words and Phrases: Phishing Management,organisation trade-offs, phishing, Distributed Cognition, ITIL

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1 Introduction

Keeping organisations secure requires effective procedures to handle reports of fraudulent emails aimed at deceiving employees into giving away valuable information. Such attacks are known as *phishing* and are often used to gain access to accounts and other information that is then used in more damaging attacks [97]. Protecting employees from such attacks is a key component of most large organisations' security plans, often including training employees on how to identify and report phishing as well as putting in place internal procedures to quickly respond to phishing reports.

Phishing is by far the most common and disruptive type of attack for UK organisations [22, 98] which can be partially seen in the amount of effort they put into managing it. Worldwide, 93% of organisations measure what phishing is costing them in terms of downtime, monetary losses,

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reputational damage, and time spent by their IT teams on remediation [79]. Organisations also spent considerable resource training end-users to identify phishing attacks, with 98% allocating more than 30 minutes to train each user and 61% training users at least every month [79]. The effort is showing results, with 63% of highly disruptive breaches being reported by staff as opposed to being found through automated monitoring [22]. The impact of on-the-job phishing training can even be seen in general user surveys where users report learning protection practices at work or learning from others who had training at work [77].

How organisations make use of phishing reports to update their defences is not currently well studied. Having a procedure in place to receive and act on phishing reports is an accepted industry best practice recommended by many authorities [7, 36, 97]. But very little is known about the practicalities and workflows staff use to accomplish these goals or how practical the various approaches are. What we do know is that effective phishing attacks can cause damage within minutes of making it to an inbox [97], so quickly responding to phishing reports is essential as it allows for rapid response and mitigation, which in turn limits the damage.

In this case study, we focus on answering how a large University in the UK handles phishing reporting and mitigation. Universities are an interesting organisation to study for several reasons. First, the education sector has the highest phishing clicking rate even compared to sectors such as finance and healthcare [97]. So Universities are a prime target for attack, and those attacks are currently successful. Second, Universities can be quite large, but their support staff are not funded or organised the same way a large financial institution might be. Third, the yearly turn over of students makes typical approaches such as training more challenging to do. Finally, Universities have valuable resources to protect. The most obvious examples are the personal details of students and staff, the content of ongoing research projects, and various intellectual properties [96]. Universities are also expected to protect access to contracted services such as the JSTOR digital library, with whom they have contracts promising to limit access to current staff and students.

Our investigation of the University began with shadowing staff working at the central Help Desk where phishing reports come in. We complemented these observations through contextual interviews with teams across the University that handle phishing-related issues.

We found that Help Desk staff become inundated by reports when large attacks occur and must balance their workload by prioritising security risks against potential impacts. For example, compromised staff or student accounts are potentially of greater threat than a single errant phishing email. Awareness of phishing incidents primarily come from end users' reports, however are not limited to this single source with alternative internal and external sources, requiring more sophisticated coordination and well-choreographed hand-offs between teams. This collaboration is seen as a distributed cognition across the teams which is essential for an effective response, enabling quick updates to automatic protections. However, lapses in current practice prevent teams from fully reflecting on incidents though practice flexibility also results in catching unexpected issues. End users who report phishing are typically given generic feedback which may not match their exact query. We also see that mitigation attempts can be hampered by the mitigating team having incomplete information, such as only looking at a single phishing example from a campaign, and therefore, missing subtle variations used by the attackers.

This case study is intended to form the basis of further studies into phishing report management processes. We believe that further research in this area will guide organisations to better inform their phishing incident plans. This case study highlights several challenges in handling phishing reports and the problems stakeholders face when managing phishing attacks. We also recommend that future research focus on augmenting phishing reporting systems using automation to help minimise staff time requirements while also making full use of every phishing report.

2 Phishing Protection Life Cycle

Here we explain how organisation phishing protections work in theory. The following description is similar to a high-level textbook description or the common narrative used at industry conferences. It also represents the goal state for many organisations, including the studied University.

Phishing management incorporates both proactive and reactive defence elements, which feed into each other. Proactive protections include activities like setting up firewalls, setting up phishing/spam detectors on incoming email, putting solutions in place to monitor and identify abnormal activity, and training end-users [75]. However, phishers are continuously trying to find new ways to bypass proactive protections, so organisations also need to have reactive processes to monitor for new attacks. These reactive approaches include monitoring automated alarms, providing avenues for users to report suspected phishing, and procedures for responding to identified attacks. Attacks identified via reactive methods are then mitigated as quickly as possible and used to update and improve proactive measures.

A typical example of reactive processes that feed back into proactive protections is *phishing campaigns*, where a phisher sends a large number of emails at an organisation, often with minor variations to each one to make them harder to detect and filter out. A phisher starts by sending one or more communications – most commonly emails – to organisation email addresses. If the organisation's proactive measures are effective, the communications will be caught by a firewall or a mail relay filter and never make it to any inboxes. The Email filters are normally made up of a combination of heuristic rules and lists of known malicious patterns (blacklists). If the communication is not automatically identified as phishing, it will appear in organisation members' inboxes.

If a phishing email bypasses all the automatic filters, users will see it and interact with it in different ways. Some users will open the emails and click on links (11%) or attempt to give away data (4%) [78]. If the proactive solutions are effective, users will be blocked from visiting the page by a firewall, their web browser, or blocked from sharing private data by internal software. If user training has been successful, some users will also identify phishing and report it, typically to an IT help desk or some other type of security operations centre. Hence, we began our research by studying a help desk.

Once a report is received, the help desk forwards it to one or more internal teams who use the content of the reported phishing email to immediately apply mitigation, such as adjusting and applying filters to mail inboxes to remove the offending phish and prevent any further interaction from users. The teams may also use log files to determine which, if any, users have already clicked on the malicious links and force a password reset. They also use the content to update proactive protections, such as updating the mail relay filter to identify and prevent similar future emails from breaching the defences again.

What should be clear from the above paragraphs is that phishing is a problem that impacts the organisation at all levels, with many teams needing to be involved in handling proactive and reactive phishing management. In this work, we focus on the phishing management's reactive processes to understand the day-to-day process of handling phishing incidents.

3 Related Work

To situate our research, we consider relevant prior research that explores security incidents management and research that specifically focused on identifying, assessing, and responding to phishing incidents. We supplement this with previous work on general IT management and best practices.

3.1 Phishing as a security incident

The cybersecurity landscape can change rapidly as new vulnerabilities and mitigations arise, resulting in distinct working practices from other general IT incidents [28]. Security incident management, therefore, involves reporting, assessment, response, and learning from incidents to improve existing security practices [59]. Phishing incidents are not unique in this regard, as response procedures are developed and refined through reflective evaluation and feedback to adapt related procedures and best practice [25, 26, 30, 65] including the development of practices that consider the range of potential attack vectors, such as Social Media [105].

3.1.1 Discovery and reporting. Security incident management begins with the initial discovery of ongoing security issues, which are identified through internal (e.g. security monitoring mechanisms and employee reports) [27, 50, 63] and external sources (e.g. bug bounties or from another organisation) [50, 61, 63]. However, it can be challenging for these external groups to identify who to report to [50]. Internal security monitoring tools, although helpful at detecting security incidents [63], can overload IT staff with a large influx of reports arriving simultaneously for a single incident [103] or from false alarms [82]. These numerous generated reports take valuable staff resources because they must be sorted through to determine their accuracy and priority before action can be taken [82, 94].

Phishing is designed to trick both email servers and end-users into thinking that they are looking at a legitimate email, making discovery and accurate validation challenging. Security managers recommend concentrating efforts on the identification of phish through employee training and preventive technical measures [51]. Automatic preventive measures are designed with the goal of reducing the number of successful attacks by passively filtering incoming emails [16, 24, 33, 48, 89] and authenticating senders to block attempted forged emails [37].

While valuable, these solutions are not perfectly accurate, nor do they protect against more sophisticated phishing attacks, such as *lateral phishing* where the attack originates from a compromised account that is already verified and trusted [32]. Human awareness is therefore seen as an integral component within organisations' security management strategies [26], as it adds a layer of security while complementing the technological controls (e.g. filters). End-user training is considered a top priority within the industry, regularly being included in annual budgets for organisations [76], and additionally an area of focus for the academic community [23, 37]. Common approaches taken to staff training include web-based training materials [66], training courses [41], embedded training (simulated phishing attacks) [3, 13, 30, 43, 53, 54], cartoon-based training [53, 88], game-based training [5, 12, 85], real-time support [4, 99, 106], and phishing stories [100]. Despite the benefits of training it has been found to not be fully effective with between 15.57% [86] and 69%[47] of people still falling for simulated phishing tests [47, 65, 86], and employees and users are still expected to report phishing [36, 66].

Timely responses greatly aid organisations to react to and mitigate attacks, reducing the number of potential victims who would engage with the phishing communication and therefore reducing or avoiding potential organisational damage [51, 97, 103]. However, the number of phishing reports is still considered too low [97] as people usually only report phishing when they doubt its safety and need an expert's opinion [10, 57], know the spoofed sender, have a desire to protect other potential victims, or perceive the email to be particularly convincing and therefore dangerous [10]. Counter to this, research has found that users may not report due to a lack of awareness of legitimate reporting channels, concerns of mishandling, and perceived self efficacy [56]. To promote phishing reporting, prior work has looked at using staff feedback after training simulation to modify policies to better align with staff needs [47]. Phishing reporting can also be treated as a problem of Communal Knowledge Management, where employees report potential phishing to a website that can be publicly accessed [45]. Praising a legitimate reporter and sharing with other staff has been investigated and shown to have a positive impact on encouraging staff phishing reports for a number of scenarios [30].

3.1.2 Incident assessment. Assessing security incidents is non-trivial as it requires trained staff to review, communicate, and identify the causes in order to determine the relative importance of issues [103]. The general public struggles to accurately identify phishing resulting in numerous false-positive reports [38, 45] which must be verified and validated [50] for accuracy as well as determine how critical they are based on potential impacts. For example, the impact can be judged based on the number of affected users, the affected services, or the type of users affected [2, 63]. Automatically prioritising sophisticated phishing emails helps the Incident Response Teams act on phishing that is more likely to harvest clicks [94].

3.1.3 Responding to incidents. Responding to security incidents often involves coordinating with staff from many areas of an organisation, and with differing expertise [8, 82, 103]. Organisations are known to use established policies and procedures to help staff follow best practice when responding, which involves investigating the cause, escalating to the required teams while simultaneously documenting all actions taken [2, 63]. While these protocols are indeed impactful, they do not necessarily match the actions staff take when handling an incident. Staff responses can be influenced by their attitudes towards the applicable security policy and their interpretation of the policy within their working context [21]. Additionally, the usability of prescribed forensic tools can impact their abilities to follow the best practices [40, 63].

While there is minimal research detailing actions around handling phishing reports by experts, automated responses to phishing incidents have proved challenging. It directly depends on the accuracy of the initial report and; therefore, requires expert human validation [38]. While complex, looking at how to backtrack to the origin of a phishing attack and analyse it can help investigating social engineering crime [58].

3.1.4 Learning from incidents. Learning from past security incidents is also challenging for organisations, with some having no formal approach to gathering lessons or redistributing those lessons to staff [31, 84], which itself may take considerable time [55]. Organisation risk focusing solely on solutions to incidents without reviewing larger policies or organisational structures [2]. Additionally, reviews may be biased when the focus is placed on rarer large-scale or severe incidents which obscures potential day-to-day lessons [2, 21] and results in overcompensation with security taking an overbearing role in incident management [21].

Best practices for learning primarily focus on the technical aspects and direct cause of incidents [93]; however, security policies may also be causes for learning. For example, Sasse and Brostoff [80] investigated the large number of incidents raised to an industrial organisation's help desk regarding password resets. The research was motivated by the high costs the organisation was incurring in help desk staff time. It concluded that modifying the current unusable password policy had the potential to reduce help desk staff time by 40%.

For phishing incidents, little is known about how to learn from them; however, qualitative and quantitative metrics are used to evaluate incident handling performance, with the latter being more dominant, such as response time, the number of tickets, and the number of incidents [51].

3.2 IT incident management

Incident management is a well-established space in Information Technology (IT) where service quality, users satisfaction, and system stability are examples of essential organisation requirements.

Many of the processes and policies implemented by organisations will be influenced by their chosen IT governance standard or frameworks such as Control of Business Objectives and Technology (COBIT) [17] and Information Technology Infrastructure Library (ITIL) [42]. Frameworks similar to ITIL dictate the structure of their IT department, guiding how to organise teams, as well as how to handle communication and coordination between teams [72]. ITIL has been found to improve overall service quality [73], customer satisfaction [73], speed of incidents' responses [68], and the number of necessary escalations [68].

However, implementing such frameworks can be challenging [44] because of the natural tension between theory and practice. For example, frameworks rightly advocate solving the root problems of identified technical issues, but workarounds are much faster and easier for teams to implement [72]. Frameworks also only offer high-level guidance, resulting in a variety of smaller implementation decisions between organisations [68, 91, 92]. With differences in implementation, IT infrastructure's performance is evaluated based on numerous indicators such as customer feedback, internal business processes, and the learning achieved [64].

The choice of tools used to manage IT incidents can have a direct impact on service quality and efficiency [20], which has resulted in research on the development of tailor-made software [20, 74] or the customisation of Off-the-shelf or outdated tools [18, 19, 87]. Still, tools alone cannot fix a broken process or workflow [18, 72]. Understanding the issues and finding an optimal workflow process before selecting the software can help organisations decide on the tools that best fit their needs.

The majority of IT incident handling begin with calls to the Help Desk and often take the shape of routine questions and issues that staff can answer confidently. However, around 10% of all calls require further research and escalation to the relevant teams [62, 83]. Research has found that end-user satisfaction is influenced by both the perceived quality of the solution [95] and their beliefs regarding the trustworthiness and level of expertise of staff resolving issues [14]. IT departments rely on several knowledge sources to alleviate pressure on staff and provide information regarding commonly reoccurring incidents. These knowledge sources can take numerous forms, including Internet repositories, cross-organisation shared knowledge base [104], Frequently Asked Questions [29], and peer advice [90].

With peer advice, for example, staff can seek their peers' help when they lack the needed expertise and the situational awareness due to the distribution of information based on the roles [60, 69], both justifying the necessity for hands-off between staff [83]. When issues regarding systems' stability occur, hands-off can involve numerous teams and staff [46] who can provide incident resolution at the right time and in the right context [83].

3.3 Distributed cognition

Distributed Cognition theory (DCog) [39] essentially describes the collaboration between multiple agents as a single cognitive systems [11, 60]. This collaboration includes human-computer interactions; thus, DCog is well matched to understand the relationship between humans, tools and artefacts [34]. In this work, we use DCog as a lens for understanding coordination between embodied agents by analysing the interactions between the people, the problem, and the tools used both in planned and emergent cases [11, 71]. *Cues*, and *Norms* are two key features necessary for supporting work in a distributed context. A cue is defined as a signal that indicates to individuals the required actions and how to enact them. In contrast, norms are the procedures that ensure consistency between individuals' tasks [8, 11].

Similar to other ITSM findings [8, 9, 60, 102], our initial findings from observing the Help Desk showed that their work is highly distributed in nature. We therefore chose to use elements of DCog in our analysis and as a lens in the discussion to understand our results in a wider context.

We are not the first to observe that DCog is part of IT management. Individuals from various units of an organisation collaborate formally and informally to address IT issues, which are characterised by pattern recognition, hypothesis-generating, and testing for uncertain success [9]. For example, Maglio et al. combined distributed cognition framework with joint activity theory to understand a specific problem-solving instance in web-based administration [60]. Botta et al. further expand on this by applying distributed cognition within the context of security management and identifying its influence over organisational processes [8]. However, little work has been done on understanding distributed cognition when resolving phishing incidents by various IS teams.

4 Participating Organisation

The University studied is an internationally recognised UK institution, which supports around 40,000 students and 15,000 academic and administrative staff members. It is distributed over multiple campuses inhabited by several academic schools, each with their own respective local IS management teams that manage their own resources. In total, there are around 1000 IT support staff.

The University's IT service management is guided by ITIL (Information Technology Infrastructure Library), a framework of best practices which is used by organisations worldwide and in diverse sectors and industries [1]. The University has adopted and adapted the ITIL framework for use by all IT services, creating a dedicated Quality Enhancement team to ensure compliance. Since the adoption of ITIL, the University has reported improvements such as the increased clarity of teams' roles and responsibilities, reductions in services outage, consistent logging of incidents, reduced running costs, and improved customer satisfaction. Improvements such as these are considered significant indicators of a successful implementation of ITIL [72]. Additionally, the University's IS achieved a Service Desk Certification [1], which is an industry accreditation program specifically designed to certify service desk quality, indicating that the University's ITIL implementation and the workflow detailed within this case is comparative to other organisations using ITIL to inform their phishing practices.

5 Methodology

The study data was collected from two sources: 1) ethnographic-style observations of the daily work of the Help Desk, and 2) interviews with other University teams. We followed our own University's ethics procedures and at all times ensured that participants were aware that participating in our research study was voluntary.

Introductions and setup. Before starting our research project we met with some of the stakeholders, namely the Chief Information Security Officer (CISO) for the University and the Help Desk manager. We explained our project goals and discussed possible project structures that would allow us to conduct the research in a minimally disruptive manner as well as provide insight that might be useful to the University. We also discussed the phishing-related issues they thought were most problematic for their teams. We used these insights as initial scoping for the semi-structured interviews discussed below.

Observing the Help Desk. The CISO and Help Desk manager confirmed that the Help Desk was the intended first point of contact for anyone reporting a phishing message. They are responsible for initial assessment of the report, escalating it if needed, and responding to the reporting user.

Given the Help Desk's central role, we started by observing their workflow. The Help Desk manager allocated a desk for the lead researcher so she could spend time with the team and

[1] https://www.servicedeskinstitute.com/service-desk-benchmarking/service-desk-certification/

familiarise herself with their work practices. She started by shadowing Help Desk staff while they were doing their daily work. Initially, she only observed and asked about the full range of their normal work practices, then in the second week she started focusing more on phishing-related work practices. The normal mode of observation was to quietly observe the staff doing their work and then ask follow-on or clarifying questions when staff were free. The observations were contextual, bordering on ethnography.

The observations were done over two months, with the researcher taking notes and spending between one and two days a week observing. They conducted focused observation of six Help Desk staff with each observation lasting 4-5 hours. They also spent time at the provided desk observing the flow of the space and briefly observing different staff as interesting incidents arose. Observed staff included experienced staff, new staff, and an undergraduate computer science student doing work experience.

The researcher was also given limited access to the ticketing system used by the University to help teams track all types of issues within the University. She also attended the training sessions for using the ticketing system. The Help Desk uses the ticketing system to manage communications with users and other teams. They refer to all interactions with other groups as "calls" and track them through the ticketing system. Calls can be digital, but they can also be a phone call or someone walking into one of the physical Help Desks and asking a question, all of which are logged in the system. The lead researcher was able to use the ticketing system to better understand how phishing calls were handled and passed between teams as well as understanding communications between the Help Desk and end-users. Additionally, the lead researcher was given limited access to the Help Desk's private knowledge base to better understand the observed practices. Throughout the research we took care to use these resources respectfully and quotes used from them in this work have been carefully redacted to protect staff and end-users.

As expected, phishing-related tasks are infrequent and tend to occur in clusters, such as when a single phishing campaign generates many calls in a short time period. Consequently, the researcher was only able to observe one live reaction to a phishing campaign. Instead, during breaks in work the researcher asked staff about their prior experiences with phishing calls. Because the ticketing system is normally open during work, it was easy for them to pull up prior phishing calls they had handled and discuss them.

Interviewing University teams. Observing the Help Desk also gave insight into the work flows of the teams they work with, most of whom use the same ticket tracking system. To better understand the work practices of these other teams, we conducted interviews. Most of the interviews were contextual interviews [35] where during or after the interview the participant showed the lead researcher real phishing handling examples of how they do their work, the systems they use, and metrics from previous attacks. Interviews were mostly conducted in nearby meeting spaces to avoid disturbing other staff.

The Help Desk manager provided introductions to other University teams that deal with various aspects of phishing, even if their involvement was minimal. We were therefore able to interview one or two members from six teams, each of whom work on a range of phishing-related issues including: dealing with users, account resetting, desktop computer rebuilding, best practice management, email relay management, interface with Office365 email, and security. Unfortunately, we were not able to interview the team that manages the network and the virtual team focused on security. In total, we conducted about 25 hours of interview. All the interviewees were experienced staff who worked for the University for more than 4 years and most of them were their team's manager or leader. The lead researcher also constructed a diagram of inter-team workflows from early observation and interview content, she then iteratively improved it by asking staff in following interviews about the accuracy of the identified inter-team interactions, procedures, and their phishing-related roles.

Team interviews started by explaining the project and the general goal of understanding how the University handles phishing reports. We then asked them to explain their team's mission in their own words and their general work practices. We then narrowed in on their phishing-related activities, including their interactions with other teams. The bulk of the interviews involved follow-up unstructured questions on issues they brought up or topics we were aware of from other team interviews or Help Desk observations.

Periodic review of findings. During the Help Desk observations, the lead researcher setup some feedback sessions with staff where the researcher summarised their findings and ask for feedback or corrections on the observations. To help guide the research further, approximately twice a month the lead researcher would give a slide presentation detailing their latest interesting observations from the Help Desk shadowing as well as the interviews to our research lab who were encouraged to ask questions and comment. The presentations included the developing diagram of inter-team workflows as well as information flows within teams and between the Help Desk and end-users. The presentations were used to help the lead researcher process observations as well as identify areas that needed follow-up to understand. As these presentations happened regularly, the lab group was also able to provide needed external clarity. Notes of key points were taken during and after meetings.

Interview data analysis. Interviews were audio recorded if the interviewees allowed it, if not, the researcher took detailed notes and completed a write-up immediately after finishing the interview. All audio recordings were transcribed by a researcher, with participant's personal information and team names being substituted for IDs both in the transcriptions and notes.

Two researchers reviewed all the transcripts and notes. Using open coding as they went, both researchers constructed their own independent codebooks focusing on the process of handling phishing. The researchers then met to discuss the process that had been observed. Through iterative coding and discussion sessions the researchers reached agreement on the workflow for handling phishing as well as the problems and friction points. Following each round of discussion, the two researchers provided feedback to the third researcher so as to guide reporting of results.

During the open coding, it became evident that phishing management at the University was an example of Distributed Cognition as the process of managing phishing clearly involved more than standard escalation of issues, and instead required multiple groups to communicate about their own unique perspectives of the incident and work together to manage it properly. DCog was therefore used to guide the analysis by putting more emphasis on the communications between teams, particularly, points where one team had access to data or resources not available to the other teams and how that information was being conveyed.

To ensure accuracy of the presented results, an early draft of this paper was shared with stakeholders and their comments were discussed and addressed.

6 Results

Phishing is handled by multiple teams within the University, including: Security, Quality Enhancement, Help Desk, Mail Relay, Mail Exchange, Network, Incident Response (IRT), and Service Delivery teams. The level of involvement of each team is different; some teams routinely handle phishing-related issues while others are only involved in emergencies or other specific circumstances. End-users are also an important part of this distributed process as they identify, report, and ask advice about phishing by contacting the Help Desk.

6.1 Phishing campaigns – managing the load

In this section we focus on how the Help Desk manages phishing calls. We observe that their largest problems involve: managing large numbers of reports coming in, deciding what reports need to be escalated to other teams, closing out the report calls efficiently, and using their own judgement on non-standard phishing reports.

The most common phishing attack handled by the Help Desk is *phishing campaigns* where the phisher sends emails to many recipients to increase the odds that one or more will interact with it. The emails are often visually similar but contain variations, such as putting the recipient's name in the email body (e.g. *"Hello Alice,"*), using slightly different body text or creating custom URL links for each recipient.

In most cases experienced by the Help Desk, a phishing campaign will use similar subject lines for all the emails. When reporting phishing, users often forward the email, causing the ticketing system to automatically adopt the subject of the phish as the subject of the ticket. If a Help Desk staff member finds a phishing email in their own inbox, they can confirm a campaign by comparing this email to those already reported in the ticketing system. It is one of the cues they use to verify phishing campaigns. Help Desk staff typically use the number of reports with similar-sounding subject lines reported in a short time frame as a signal of a campaign. Often, such sets of reports will happen in the morning due to users checking their email then.

> [Help Desk] Morning usually is the peak time for us. We receive calls between 8 and 9 am because usually staff will come in the morning check their emails and report phishing.

After determining that they are looking at a phishing campaign, staff select one or more of the calls to escalate to the appropriate teams. The remaining similar-subject calls are either temporarily ignored by staff or grouped together into a single open call to reduce clutter in the ticketing queue. Later in the day, when new phishing reports have stopped coming in, a staff member will voluntarily go through and close all phishing calls at once.

The above workflow has naturally evolved as a way for Help Desk staff to manage phishing reports alongside their other service delivery tasks.

6.1.1 The number of phishing reports can overwhelm. The Help Desk's primary goal is to optimise the number of calls processed, either by closing or escalating them, ideally taking less than 15 minutes for most calls. A phishing campaign is problematic for the Help Desk because it generates a large number of phishing calls, each of which must theoretically be handled individually, taking time away from other calls. For 2019, they received phishing-related calls on at least 20 days out of every month, with call counts ranging between 2 and 170 per day. While that number may seem large, it only represents a small percentage of the University reporting phishing. If a theoretical phishing campaign were to target all University staff and students (about 58,000 people) and even 1% were to report it, that would be 580 calls, well above the normally observed number.

Most of the teams, including the Help Desk, agreed that having people report phishing was needed as it is the cue for identifying campaigns. However, they also recognised that the University did not have the resources to look through all the phishing reports. An Quality Enhancement staff member quote explained:

> [Quality Enhancement] We want people to report [phishing emails] but we want to be able to manage the load of calls. The problem is we cannot manage them.

The Security team similarly recognised the problem of a lack of resources impacting the Help Desk's capacity for managing reports:

> [Security] At the moment we don't have the resource to have someone look at them and triage them which is our main problem.

This overloading problem resulted in the Help Desk adapting their practices to fit the ticketing system's functionality, as we discuss later. Another tactic the Help Desk uses is to get help from other teams, such as the Mail Relay, to block still incoming campaign emails and remove existing phishing from peoples' inboxes. Doing so has positive security impacts, but more practically, it stops the flood of reports making it a strong immediate motivator to react fast.

Help Desk overload also impacts the University's ability to send simulated phishing messages to end-users as part of security measurement and training. Sending such fake phishing emails is currently an industry best practice to understand how well-trained staff are and if the procedures put in place are effective. However, when the University attempted such an exercise, they unintentionally overwhelmed the Help Desk with calls as the Mail Relay's normal work-management strategy of quickly blocking the incoming attack cannot be used on simulated phishing. The overload damaged the Help Desk's ability to do their daily tasks and their ability to provide customised feedback to reporting users, resulting in a loss of a potential user-training opportunity.

> [Security] The problem is when people then report [the fake phishing email]; there is no inbuilt system on our email that says "Wait, this is a fake one, calm down". So with the issue in the Help Desk, Help Desk was completely swamped and that what happened after we ran the simulation the first time.

As a result, the Security team temporarily stopped sending fake phishing emails and are working on finding ways to better conduct training and testing. Including agreeing to be part of the research project described in this paper as an effort to better understand how phishing reports flow through the organisation and where provisioning is needed.

6.1.2 Deciding what to escalate so as to not waste other teams' time. The main point of the Help Desk is to decide what does and does not need escalation, so other teams only spend time on problems that require their expertise. Hence, one of the Help Desk key tasks is triage, where they sort through reports and identify which calls require escalation to the appropriate team.

In addition to wasting time, escalating unnecessary calls can also result in a polite rebuke from the other team. We observed several situations where a call was escalated, and the other team responded that they had already handled this one in the morning, or that necessary information was not present. Consequently, the Help Desk staff try only to escalate calls when necessary.

> [Mail Relay] If they are asking us to block a specific email and they told us 10 times already, then we do not need to see it again ... but what we do not want is the Help Desk passing all the hundred calls to us just saying the same thing "This person received a phishing email". We only need to be told once.

Given the need for human validation of potential phish, there exists no formal approach for identifying the 'correct' cue and the applicable actions. Therefore, we detail the range of identified cues and the associated norms made available to Help Desk staff.

Is the reported phishing email from a University email address? Compromised University accounts are a serious problem, so if a reported phishing email is from a University email address, the Help Desk will handle it differently. We further detail how compromised accounts are handled in Section 6.3.

Is this a campaign or a one-off attack? A key criterion for the Help Desk is the number of reports. If there is only a small number of phishing reports, then requesting action to block incoming emails is likely a waste of other teams' time. The attack may be a one-off, or the user could just be confused. Neither case justifies escalation.

Looking at the phishing emails reported during May, we found 9 phishing campaigns with more than 4 phishing reports, 12 campaigns with 2-4 phishing reports, and 40 phishing reports of single phishing emails. Using the helpline strategy, only 21 calls would have been escalated in May.

Do other teams already know about this phishing campaign? If other teams are already aware of the problem, then escalating again is unnecessary. So before escalating a call, Help Desk staff check that it is not already being handled. The Help Desk maintains a separate list of phishing emails that are logged with Mail Relay. The list includes the subject lines of phishing calls that have already been escalated.

> [Help Desk Knowledge base] Due to the current number of phishing attempts being made on our email service, we really need to monitor what we have sent to Mail Relay so we don't end up inundating them with calls.

Sometimes other teams become aware of a phishing campaign through other sources, such as getting the phishing email themselves or being notified by another University, detailed in Section 6.4. When that happens, they notify the Help Desk so that they do not escalate the calls again. However, the various sources of notifications resulted in missing them or delay the response process. In the below example, a call was escalated to the Mail Relay team, who then deescalated it because the IRT team had already created an earlier call for the same issue which the Help Desk would have been copied in on.

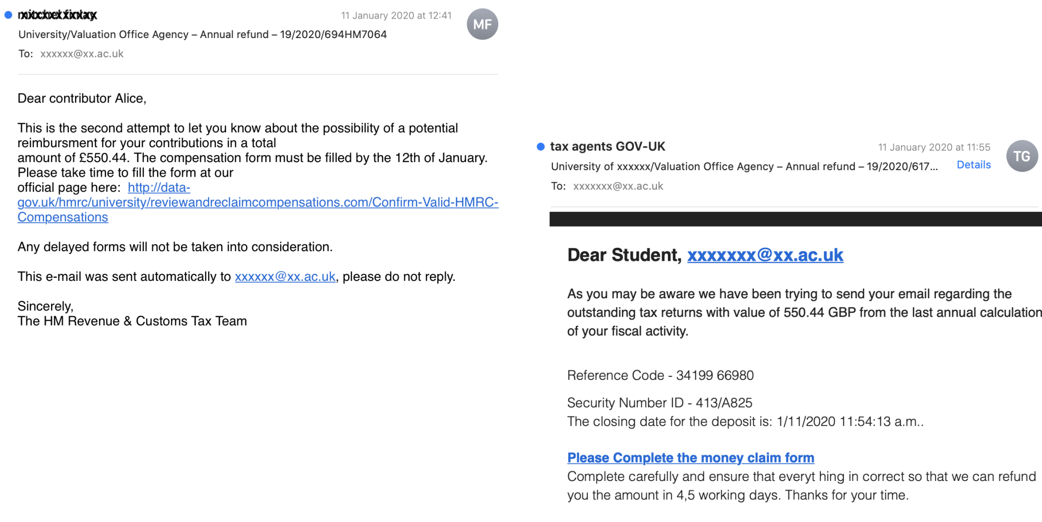
> [Mail Relay deescalating a call] The Help Desk were passed a call about this from IRT earlier today.

Is all the necessary data present? When reporting, users often forward the problematic email or provide snippets of it in their communication. Nevertheless, the specialised teams such as Mail Relay need the header data from the original email, which is not included when the email is forwarded.

Fig. 1 shows two examples of why the original emails (*.eml* files) are needed. Both pictured emails are from the same campaign sent within minutes of each other to two Lecturers in the same University department. To a human, they are obviously part of the same scam, but they are quite different to a computer. The sender emails are different, the use of link text differs, the email text body itself is different, they have different HTML formatting, even the subject has variations. These example variations are consistent to those seen in prior work [57, 94]. Automatically identifying this scam from the email of a whole University is not possible using only the pictured information. However, the *.eml* files contain additional information such as a list of all the email servers the email passed through, their IP addresses, encryption signatures, and any checks performed by the servers.

The easiest way to get the header information is to have the user save and send the original email as an *.eml* file. Reporting tools, such as ones the University is currently pilot testing, will attach this file to the phishing report automatically, but at the time of observation, the only way to get it was for the user to provide it explicitly. To save time, the Help Desk has a pre-written response text, called a *Standard Solution* (SS)–detailed in Section 6.5, for asking the user to send the email as an *.eml* file, including instructions on how to do so. So if the *.eml* is missing, the staff managing the call will ask them for it using the SS. The user may then take some time to respond or not respond at all, delaying the report escalation.

Escalating the call. Once the Help Desk has all the needed data, they again check that the call has not yet been escalated, and if not, they escalate it. First, the Help Desk staff update the aforementioned list of escalated calls with their phishing incident's subject and then escalate the call to the Mail Relay, Mail Exchange, and IRT teams. Typically the escalation will be done on a single call so that all three teams can see comments made by the others. The purpose of the escalation to



(a) Phishing email sent to “Alice”. (b) Phishing email sent to “Bob”.

Fig. 1. Phishing emails sent to two University Lecturers in the same department on the same day. Mildly edited to make them anonymous.

the three teams is to ensure situational awareness across the ITSM department; however, only one team may work on the call depending on the situation.

6.1.3 Closing calls is also time consuming. Closing a phishing call involves providing feedback to the end-user and marking the call as resolved in the ticket tracking software.

> [Help Desk] We would escalate one of the calls to the appropriate team to action in terms of blocking at the relays or removing the offending email from mailboxes. The rest of them we would just contact the user to say delete the email, change your passwords if you’ve clicked on a link etc.

To do so, a staff member has to look up the phishing SS in a long list, pick the appropriate one based on the user query in Table 1, select it, send it to the user, copy it to the call history, and then mark the call resolved. The actions are fairly simple, but when 100+ calls all require the exact same set of actions, it can get repetitive.

To combat this, the Help Desk staff will tag all incoming phishing calls with unclear subjects by adding “[Phishing]” to the subject and leave them open on the system. They will then wait about 30 minutes for any further calls or till the rate at which reports come in slows and then bulk close the calls via an internal communication system. They then select everything either tagged “[Phishing]”, or that is clearly part of the day’s phishing campaign, and close them out all at once, sending all the reporting users the same SS and marking all the calls as resolved as one bulk action; thereby, saving everyone quite a bit of call-closing time.

> [Help Desk] Sometimes the volume gets beyond us, we are not going through this one by one and contact each user individually with SS. We are gonna just bulk and close these calls with the generic bulk closure message, it goes out with basically goes out and say if you want more information, look at the call in the service portal because sometimes we don’t have the capacity to chip through these.

6.1.4 *Help Desk staff are relied on to use their own judgement to identify non-standard problems.*

While the Help Desk heavily relies on standard protocols, procedures, and processes they also encourage their staff to use their own judgement around how to handle each call and provide them with the tools to do so. While seemingly unremarkable, it is important to understand that staff are encouraged to handle calls within minutes and therefore tend to apply the heuristics described above to handle phishing calls quickly. Here we detail a couple of situations where staff noticed something odd and followed up in a non-standard way.

When shadowing a Help Desk staff member, we observed them take a call from a single phishing report which would typically be closed without escalation. The report complained that the forwarded phishing was impersonating their Department Head and asked the Help Desk to block the emails. The Help Desk staff member thought that the phishing email was particularly believable and therefore might constitute a high risk, but they were still uncertain if it was worth escalating. So they used a University provided message trace service on the email's from address and found that the phisher had sent the email to around a hundred users. So they immediately escalated it to the appropriate teams.

In a separate instance, the Help Desk received a large number of calls where users reported a legitimate email from within the University as phishing. The Help Desk team investigated the reasons for that misjudgement and found that an email sending service had been used that made the sent emails look like they might not actually be from the University.

> [Help Desk] We have false positive occasionally. It has been assisted now. I am trying to think what is the bulk mail. XX mail is a commercial book mail relay that you can buy into that allows you to send lots and lots of emails to target audiences. Certain colleges, were using [it] for email campaigns and things like that. The problem with that is not coming form the University email address. It has The University name in some part of it but it is not xx.ac.uk and people were reporting that it is phishing but it is not. We are not having it anymore because changes were made to make the email that is sent to people more obvious that it is part of the University. It should have the University logo, University address, and looks professional.

To address the problem, the University banned the use of email services that do not comply with best practice, such as providing URLs hosted under the University's domain.

6.2 Converting escalated calls into protections

In this section we discuss how the Mail Relay and Mail Exchange teams handle escalated calls from the Help Desk along with other teams. Handling an escalated call most often involves finding a reliable way to identify the phish and then applying that method across several systems. Both of which may require hand-offs between several teams to find solutions and implement them. Also, some phish simply cannot be blocked or require several attempts to do so.

A large component of handling an escalated phishing call is ensuring that University users are protected from the reported phishing attack. People have a wide range of skills at identifying phishing [49] with some quickly reporting the phish and other more vulnerable users clicking on malicious links. To protect these vulnerable users, teams can use reports to remove phish from inboxes as well as prevent new phishing from entering the University email system. Doing so primarily falls to the Mail Relay team who handle incoming and outgoing emails and the Mail Exchange team who handle stored emails as well as emails managed by Microsoft's Office365. However, other teams may be required if the situation dictates so. Phishing campaigns can vary dramatically in sophistication with the process being straight forward if all the phishing emails share a unique feature, such as all coming from the same email address. But other phishing campaigns can be more complex (e.g. Fig. 1).

6.2.1 Finding a common reliable factor to protect users. Many features are used to block phishing, but some of the most common are the from address, subject line, and any mail relays listed in the header. The teams use a combination of experience and educated guessing to select potential features and then run practice searches to see how effective it is.

While the main process is fairly basic, doing it reliably is not easily learned as it requires knowledge of email header's structure as well as an understanding of IP addresses and IP address ranges. Feature selection also has to be done carefully so blocking and deleting will not interrupt users' work. A simple example might be a phishing attack that closely mirrors a genuine Dropbox email. If the Mail Relay team chooses to block on features that are also shared by real Dropbox emails, they could inadvertently damage all users' ability to interact with Dropbox. Universities are also complex, with staff working on a wide variety of problems, using a wide variety of tools, and collaborating with a wide variety of people. So blocking whole IP ranges, domains, or tools cannot be done lightly.

The effect of blocking or deleting emails can also range from time consuming to impossible to reverse. The Mail Relay team can trap emails in quarantine and then release them for delivery if they were incorrectly identified as spam. However, when the Mail Exchange team deletes an email, it is permanently gone and cannot be recovered. As a result, the Mail Exchange team has internal procedures around email deletion, such as requiring the manager to approve all deletion commands. They also require specifying a date range, from address and subject line in the deletion commands to limit potential damage.

> [Mail Exchange] Within Office 365, you can do what we call it content search. There is one various procedures to ensure we don't do it unless we have the approval to do it but yes we do have the ability to do that and any thing we do is fully auditable.

6.2.2 Fixing requires knowledge, resource, and responsibility. University teams are generally either centred around resources that need to be managed (e.g. Mail Relay) or around specialised knowledge that takes time to accumulate (e.g. Security). Knowledge regarding how to address a phishing incident is often located in many parts of an organisation. This situation is fairly common in IS support as different teams and members often gain in-depth understanding of the systems they work in and then collaborate with others as needed [46]. In terms of phishing, teams need knowledge, both in terms of making non-disruptive changes to running systems and making changes that are likely to have the desired security outcomes. Large computing systems are made of many interconnected components where a single change can have unexpected side effects. To balance this distribution of knowledge and ensure their changes meet the best practices, the University teams actively coordinate with the resource-based teams to make the actual changes to the system and also to ask for advice and sign-off from other teams, such as Security.

Access to resources, such as systems, services, and channels, is also often restricted to ensure that people with insufficient knowledge do not make well meaning but potentially very problematic changes. For example, it would be much faster and more efficient if the Help Desk could directly go from identifying an accurate phishing report to applying an appropriate rule to the mail relay to stop new phish (and reports) from coming in. However, as the Mail Relay team notes below, knowledge of how to modify the relay safely is not quickly learned.

> [Mail Relay] It is so complicated only experts can understand [filter rule construction], I don't think the Help Desk have access to the black list.

Consequently, the Help Desk cannot edit themselves and instead raise a call and wait for the Mail Relay team to take action.

University systems also frequently impact each other, requiring teams to coordinate or ask each other for help addressing an issue. For example, a Mail Relay team member recalled a prior phishing campaign when so many emails were coming in the same time, causing the relay server to experience overload. So despite applying mail filtering rules, the phishing emails were still negatively impacting users' ability to get emails. To solve the problem, they reached out to the Network team to temporarily block all incoming emails from the phisher's IP address range. Doing so reduced the load on the mail relays and resulted in a successful blocking of the malicious emails with minimal impact on University services.

> [Mail Relay] We do communicate with Network team in active attacks from a specific IP. Network team will block the traffic to save resources.

In situations requiring specialised knowledge, teams may require consultation, guidance, or sign-off from other teams before enacting a change. For example, phishers will sometimes send emails from an IP address range to make blocking the email harder. IP address allocation is a constantly shifting feature on the Internet as addresses are assigned and reassigned to different Internet Address Registrars. Some ranges are unallocated and can be safely blocked, while other ranges might be used by valid users. The Mail Relay team's knowledge does not necessarily include an in-depth understanding of the current IP Address allocation issues, so when choosing to block IP ranges they may consult with teams like Security or Network who have this knowledge.

> [Mail Relay] We consult Security with policy and security. For example, if we have an attack from a country, we will escalate it to them for decision ... We can't block all the emails from Nigeria. It will damage our reputation when someone from Nigeria tries to contact us. We should just balance the cons and pros of each rule. Many emails will be trapped by blacklists.

While some teams play a direct role in the day-to-day responsibilities of handling phishing, others monitor the ongoing incidents and processes used. For example, the Security team observes the internal processes and advises on change to better promote security practices. They do this by tracking ongoing security incidents handled by the IRT through monitoring of the IRT's resources:

> [Security] We have access to the IRT's inbox. So we can see what is coming in and out. So, we know what is happening and we can actually see the [ticket system] calls that are assigned to IRT's inbox. So that how we know what is going on.

6.2.3 Some messages cannot be blocked or removed from inboxes. Sometimes, even with the help of multiple teams, phishing emails cannot be reliably blocked or deleted. During the data collection, a large phishing campaign hit the University. It was sent from different email addresses and had unique subject lines, often involving recipients' names. The Mail Relay applied several blocks on the relays, but the number of from addresses involved made it challenging to fully block or remove them from users' inboxes. Instead, the Quality Enhancement manager relied on the users as the last point of defence and sent an email on to all University members explaining the email characteristics and asking them to delete any email that matched.

> [Quality Enhancement email] ... the University is receiving a very significant number of phishing attempts which have the recipient's name in the subject field and some text in the body of the message ... If you have received a message like this can you please delete it without clicking on any links within. If you have received a message like this and clicked on the link, please contact [Help Desk] for advice.

6.2.4 Email blocking does not always work on the first try. Normally, the Mail Relay team will use an escalated call to construct a blocking rule that effectively blocks all emails of that type. But sometimes the blocking rules miss a portion of the campaign.

In the following case, a campaign had happened, the Mail Relay team had been escalated to, and end-users had been sent the SS. The user questioned the block's effectiveness and sent a follow-up call in response to the first phishing report to ensure that a block was correctly applied on the mail relays. However, they were not satisfied with the response and sent in yet another call.

> [End-user] Got another three e-mails through from the xxxx@gmail.com address, so that the block you have put on does not seem to be effective. Could you check what has gone wrong?

In response to the initial call, the Mail Relay team had applied a block based on the phisher's email address, but the phisher was sneaky and bypassed the block. A Help Desk staff correctly identified that the above email was an indication that the Mail Relay team's solution was not working and escalated the call despite it already being on the list of previously escalated calls. Using the new information, the Mail Relay member consulted the staff within the for a solution; thus, Mail Relay team expanded their rules to look for the problematic email address in multiple header locations. Also, given the sneaky attacker behaviour they also chose to block all email traffic originating from the IP range the attacker was using.

> [Help Desk escalation] Hi Mail Relay, The block on the below email put in place in call xxxx2241 appear not have worked. Can you advise on what else can be done to try and stop these emails getting through?
> [Mail Relay member 1] Any idea why my entry in the access file didn't work?
> [Mail Relay member 2] The simple way of blocking an address relies on the return path - which is what the mail system sees - being the same as what is in the from header. That is usually the case, but in this case it was not. They are being rather more sneaky than usual. I have put in a different sort of block which should block anything with "xxxxxxx@gmail.com" in the From: header. I also identified four network [IP] blocks from which these spams have recently originated (though there may be others I have not found) and blocked all traffic from them.

6.3 Compromised accounts – a serious reputation and workload problem

Accounts can be compromised as a result of a successful phishing attack. Once the victim provides their credentials on a fake web page, the attacker can use them to gain access to the victim's accounts. In this section, we discuss University practices of reported compromised accounts. More specifically, we detail the cases in which they hand-off the calls to IRT team or rely on users to revoke the attacker's access to their account. IS teams have strong security awareness with regards to compromised accounts; thus, reacting on them is independent from reacting to other phishing incidents.

Compromised accounts were found to be mutually understood by all teams, and were unanimously identified as definite security concerns, given that multiple services can be accessed using the University's single authentication system. Among other actions, they can use the accounts to gain access to send out more phishing emails. Similar to findings from previous research [32], staff from Mail Relay, Help Desk, and Mail Exchange believed that this is the most common scenario for compromised accounts in University.

> [Mail Relay] Every time an account is compromised, effectively theft of personal information.

Blocking phishing emails is done internally by the spam filter on the mail relays managed by the University's Mail Relay team and also by the default spam filter on Office365 Exchange Server managed by Microsoft. Phishing emails from compromised accounts are treated more seriously than other phishing emails since they do not go through the relay's spam filter and they get a lower spam score from the Exchange filter because they are from the same domain (internal users), which is considered trustworthy.

> [Mail Relay] Messages sent internally from one student to another student do not go through any of that relay's scoring. It is all set within Microsoft Office365.

> [Security] Add scores to the emails is the things that Office 365 and Microsoft do. They have what is called spam ratings and they basically just go: "this looks like spam and this does not"„ based on the huge number of criteria. We use the scores to some extent to block things that have basically the highest score because always entirely they will be.

Compromised accounts are sometimes used to send out spear and loosely targeted phishing emails aimed at specific groups of individuals. Both of these attacks are hard to detect by end users [49]. We observed several cases of these attacks while shadowing the Help Desk staff. In one case, the attacker compromised the victims' account and used it to send several emails to other University members hoping that one of the recipients knows the victim and replies to the attacker.

> [Help Desk] The user here reports [Spear Phishing]. So the user was aware of the phishing type. The email said only "Are you available?". If the user knows the person who sent the email, they will communicate with the attacker and maybe transfer money to them. Mail Relay told us that the sender accounts are compromised.

Compromised accounts also pose a reputation problem. They can be used to send a malicious email to other organisations with the University's name associated with it. Considering that University is moving toward applying the cryptographic signature of the University's mail relay, other organisations use these signatures in their spam filters, so email coming from a University compromised account is more likely to make it through other organisations' spam filters and harm reputation when their teams have to handle the messages.

> [University public Knowledge base] Phishing campaigns lead to compromised accounts and as it stands currently, risks the integrity of the University's reputation, data and ultimately, University business.

Compromised accounts are one of the most critical impacts of phishing campaigns as they can quickly snowball in scale as internal emails can reach more users who can potentially become compromised and phish other users.

Despite their importance, fixing compromised accounts is time-consuming and hard to do at scale as each account must have its password reset individually.

> [Mail Relay on behalf of IRT] The problem we have is that often in the time between the initial compromise and the sending of spam and then us trying to delete that phishing from other users mailboxes, even if that is 10 to 15 minute, we get dozens of people who then get compromised. We then have an ongoing problem of phishing going around the University, moving from one person to another person to another person, and we can't keep deleting them all. So ideally, what we want to do is stop getting them in the first place, which is a really difficult thing to do.

6.3.1 Reported phishing from new compromised accounts should be escalated. For every phishing incident, the Help Desk staff look at the sender of the phishing email; if it comes from an internal user, such as a student, it is considered a compromised account and requires more immediate actions beyond those discussed in Section 6.1.

The escalation of compromised accounts is similar to the escalation of phishing campaigns in that only new cases should be escalated; however, the Help Desk should escalate one call for every phishing campaign whereas all distinct compromised account reports should be escalated.

To ensure the account has not already worked on, the Help Desk staff normally look at the list of blocked compromised accounts provided by the IRT team and only escalate the call to the IRT if the account is not on that list. Unlike the list of phishing emails logged with the Mail Relay, the known compromised account list is maintained directly by the IRT team. Unlike phishing escalation, Help Desk staff are not expected to verify if the account is compromised before escalating it.

> [End-user] Just to make you aware, please see above most likely a phishing email that has been sent from a student account.
> [Help Desk] Hi IRT, I can't see this account on our list of compromised accounts.
> [IRT] I see no evidence that the account is compromised.

A Mail Relay staff on behalf of the IRT team was positive on hand-off calls that ask if an account is compromised or not.

> [Mail Relay] If the Help Desk are asking us to look at a specific email from different account saying is this account compromised, we will look at each individual one of those.

Reporting compromised accounts is necessary since IRT staff can use it to trace other compromised accounts. The example below illustrates how the IRT staff used the report to reset the compromised account, escalate it to Mail Exchange to remove the emails, and also lock other user accounts proactively because they were observed sending the phishing emails from the same location and at the exact time.

> [End-user] I received the attached email over the weekend, I think it might have gone to other staff. It seems to be a phishing attempt and comes from what purports to be a student's email address. I did not click the link.
> [Help Desk] Hi IRT, see attached email and compromised account.
> [IRT] Passwords have been reset. Call also sent to Mail Exchange to delete the emails. User1, user2, user3 are also sending phish around the same time from the same place. Passwords have been reset.

6.3.2 Helping users who self-identify potential compromise. Some users contact the Help Desk looking for advice because they clicked on a phishing email, resulting in a compromised account.

> [End-user] I opened a dodgy email and now my email has been hacked and is sending spam all over, what should I do?

In this case, the Help Desk asks the user to change their password, and no escalation is required because in most cases changing the password will lock the attacker out. Time-wise, this is the best-case scenario since the user can solve the problem and do not lose any access to their account. Supposing a compromised account is identified by someone other than the owner, then any calls have to be escalated to the IRT team who resets the user's accounts with a temporary password and asks the user to change later, which takes more time for everyone.

This scenario aligns with Help Desk strategy of shifting the responsibility to users to reduce future calls when the user re-encounters the same issue.

> [Help Desk] We also rely on "shift left". Moving everything to the users. E.g. knowledge on the University website so when users contact the Help Desk, they will receive a link if users can help themselves.

6.4 Information flow patterns are not in fixed orders or directions

While our focus started with the Help Desk, awareness about phishing campaigns and compromised accounts may actually originate from various sources. In this section we detail how teams become aware of an ongoing campaign by discussing the notification procedures within teams or from outside the ticketing system. Teams may become aware of incidents by receiving notification from a number of internal and external channels, including the team's own monitoring systems, a UK-wide educational network called Janet, and the contracted organisation that handles out-of-hours Help Desk calls. Regardless of the source used to identify an ongoing phishing incident, each team works to ensure that all relevant teams are aware of new attacks so as to maintain organisational situational awareness. These cues result in responsive action which may not be reported to helpline staff, but will result in communication between service teams as they coordinate operations for protection.

6.4.1 Phishing awareness can originate from within teams. Standard monitoring practices by teams can identify suspicious activity within their systems or through their own personal email inboxes. Once aware, teams proactively adjust their systems to protect users from phishing attacks. For example, Mail Exchange can notice phishing incidents if a compromised user exceeded the limit on sending emails.

> [Help Desk] Generally, Network look to see when there is strange activity on the network because they have the network logs. So they have some massive traffic ... So what you got here about quota limit, they see some of the other behaviour around that kind of concept that things like massive downloading from users who wouldn't normally do that and then they will feed it in there and say OK here is the thread and start investigating.

Similar to the Help Desk, the team creates a call based on the observed problem and escalate it to other relevant teams to mitigate their own systems. Maintaining vigilance for anomalies allows teams to react immediately.

6.4.2 External partners can inform teams. Apart of the University IS teams, awareness of phishing incidents might originate from external partners. For example, many Universities in the UK gain access to the Internet through the Janet Network, which is a dedicated network infrastructure for the "UK research and education community"[2]. If a Janet admin identifies a serious attack, they may choose to block URLs associated with it UK-wide and notify Security or Network teams directly.

> [Quality Enhancement] We have for example a huge issue last year where a lot of different Janet organisations were being attacked and Janet is the education network. What happened is gradually different universities started to get attacked but some universities put proactive steps because they were able to share that information to reach a solution.

Janet also informs the Network team about outgoing suspicious communication, so the network team become aware of compromised accounts or machines.

> [Help Desk] They are all interlinked because you could end up getting referral from Janet on the basis that someone clicked on a phishing email and gave out some details which is compromised their accounts and it has downloaded some sort of bot that then start trying to connect to all over the world throw your traffic out and trying to contact other hosts which are known to be malicious.

Another external source of information is NorMAN. NorMAN is an Out-Of-Hours service to support University members 24/7. After the work hours, the Help Desk directs all the calls to the NorMAN support desk. NorMAN cannot solve all the calls because they do not have access to the ticket system, so at the end of their work, they provide a report about resolved and not resolved calls. Then, the Help Desk integrate all the calls to the call system and resolves all the calls which could not be handled by NorMAN.

> [Help Desk] NorMAN will try to resolve some of the issues but not all of them because they don't have access to [ticket tracking] services.

[2]https://www.jisc.ac.uk/janet

In the case of phishing attacks, NorMAN staff reply to users without escalating the calls to other teams. Information about any phishing campaigns is included in the NorMAN support report for the Help Desk so they can prepare for the potentially large number of early morning calls and escalate them to the other teams. During shadowing, a first-line staff retrospectively told us how they learned about an ongoing phishing campaign from the manager relaying a NorMAN report.

6.5 Providing feedback and guidance to end users

The above sections highlight the importance of user generated phishing reports in detecting and managing phishing attacks. In this section we look at interactions with users, particularly the use of pre-written standard solutions and impacts of bulk closures on users. Standard solutions may save staff time, but potentially at a risk to user satisfaction which is seen as a necessary component of service quality as well as likely influencing users willingness to report future phishing the encounter.

Users contact the Help Desk to ask about guidance around phishing. For example, a user may be uncertain if an email is real or not and is asking for guidance about if they should respond. They may have already taken some action, such as reporting the phishing to their bank, and are asking if that was the correct course of action. Or the phishing email may be threatening them in some way, such as threatening to shut down their account, so they want reassurances that their account will not be deactivated. Some users even engaged with the phishing before realising that it was fraudulent and are seeking guidance about how to best manage the situation.

Help Desk staff endeavour to respond to every call in a professional way that promotes user satisfaction and resolves any service problems. However, the number of calls and time limitations can impact communicating with users.

6.5.1 Standard solution (SS) design. While the range of queries can be broad, most users are looking for only a small set of guidance, such as reassurance that the email is indeed phishing, that they have done the right thing by contacting the Help Desk, that they should delete the email, how to ensure that their device is malware free, and how to protect their account if they did interact. The high overlap in needed guidance is a perfect match for a Standard Solution (SS) where several sets of guidance can be written by a qualified person and then re-used. Having an available SS is also helpful for Help Desk staff who may not themselves be experts in phishing and may feel uncomfortable providing self-written guidance to others. SS also allow them to quickly provide consistent professional guidance with detailed steps.

The benefits of the SSs were acknowledged by Help Desk members we spoke to, with all reporting that they reply to all phishing calls using them. SS were also valued for the time they saved first-line staff. Instead of working 5 minutes on every phishing call and writing a reply to every phishing email they receive, first-line staff can quickly use an SS for common phishing calls.

SS content design. Phishing-related SSs were developed by the Help Desk based on the most common reasons for contacting the Help Desk and focus on: 1) thanking users who reported phishing emails, 2) confirming an email is phishing, 3) confirming an email is not phishing, 4) helping users who clicked on links, and 5) informing users about phishing simulations. Contents of phishing-related SS are detailed in Table 1.

The wording used in the SS were carefully chosen through a collaboration between the Help Desk and Security teams to ensure that it both matched what users were asking and that the responses were technically accurate.

User's query	Summary of SS content
Ask if an email is phishing	Yes it is, staff report informing email team, and provide mitigation steps in case the user clicked on links or opened attachments.
	No it is not, staff manually write the reason(s).
Report phishing	Thank them, staff report informing email team, and provide steps if clicked on links or opened attachments.
Report phishing (simulated attack)	Thank them, inform that it is simulated, educate user, no action required.
Clicked on a link	Ask them to delete the email immediately and follow provided mitigation steps.

Table 1. Phishing Standard Solutions used by the Help Desk when responding to phishing-related calls.

> [Security] And we have occasionally gone to [the Help Desk], the wording you are means the people around being inclined to not report any more. Why you are doing it this way. So, there is some back and forth.

Consistent messaging. SSs are also helpful because they provide consistent messaging to users which is generally considered an effective approach in public safety communication [81]. The Help Desk manager was a proponent of consistent and accurate communications because they felt it would enable them to develop a trusting relationship with users. Managing relationships with users also partially motivated the creation of multiple SSs addressing different common requests, because they felt that the template variations would signal that the Help Desk is listening to each user and providing custom feedback.

> [Help Desk] We focus on the consistency in answering users. It is important to build up the relationship over the years.

> [Help Desk] Standard solution is used for specific processes such as phishing. When a user forget their username, we give them technical process.

6.5.2 *Bulk closing calls has costs.*

As discussed earlier in Section 6.1, we observed that Help Desk staff typically read the first few phishing calls in a campaign and then assume that the remaining reports with similar subject lines have similar content and should therefore all receive the same SS. They do so to efficiently use valuable first-line staff time. However, bulk closures can result in sounding tone-deaf as well as lead to missing important information.

Some users may be giving or looking for information beyond reporting or inquiring if the email is phishing. The bulk closures can cause these calls to be missed. For example, one of the campaigns was a cyberbully type of phishing attack, where the attacker threatened to share victims' unpleasant secrets with everyone in their address book. After the bulk closure of the emails, a user replied to the SS trying to get an answer to their specific question:

> [End-user reply to SS] I asked whether I should be informing police - given than this was an attempt to extort money from me by threats? It is not simply a phishing email.

Bulk closures can also result in missing valuable information from reporting users. For example, the user below noticed that there were different senders in a two week-long campaign.

> [End-user] Back in February fake emails of the "are you on campus?" type were being sent in the name of Miguel, with address miguelxxxx@gmail.com. I reported this.
> I just got another one, this time from a different address, miguelyyyy@gmail.com.

The user makes an important point about how the phisher is using multiple addresses, which may be helpful to the Mail Relay and Mail Exchange teams. Unfortunately, emails like this one are at risk of being missed during a campaign because of bulk closure.

7 Discussion

7.1 Phishing management is a distributed cognition process

Prior research has found that information service management is, by its very nature, a distributed cognitive (DCog) process [8, 9, 102] that requires hand-offs between distinct teams [60]. In a DCog system the cognitive elements of a problem are solved not by a single person but by offloading them onto an environment made up of a combination of people and technology. Because the technical systems of a large organisation, like a university, are managed by multiple teams who must pass problems between them, they often evidence DCog in their problem solving approaches.

However, that does not necessarily mean that all processes in service management involve DCog as many tasks may only require a single person or small team. In this work we have shown that phishing management, at least in this case, evidences many of the elements of DCog. Phishing touches on many distributed elements of the University's IS operations, people from different teams collaborate to pool their knowledge, unique system perspectives, and technical ability to solve phishing problems which occur on a nearly daily basis. To do so effectively, they also make heavily use of tools like ticketing systems, knowledge bases, jointly maintained lists, and standard solutions, all of which allow them to communicate and share knowledge between members to jointly manage phishing. Ticketing systems allow for quick communication that is archived and visible to all involved teams, enabling joint problem solving. Tools like knowledge bases and jointly maintained lists allow for storing of knowledge for use by other teams or future team members. For example, the maintenance of lists of known compromised accounts by various teams so the Help Desk can accurately respond to users. Standard solutions are also an interesting inter-team example where the Security team worked with the Help Desk to construct user-facing feedback about phishing that is accurate which the Help Desk regularly uses in their communications.

Our work suggests that phishing management might be a DCog system for organisations that divide their IS operations up into different teams and have those teams coordinate through ticketing system like tools. The observation has wider implications because it allows for a deeper and more nuanced understanding of the workflows than is necessarily presented in this case. Break downs in DCog systems are evidenced partially through challenges that the people involved experience. Such as having a fragmented common ground where each individual has their own set of knowledge that does not necessarily overlap well with the knowledge of others, requiring not only information sharing but also facilitating collaborative operations. In DCog, information also tends to pass through networks of people either directly, or more as we observed, through the passing of a ticket that progressively builds up contextual cues. This dialogue between teams is needed because no one individual has full understanding of the system or the problem, necessitating the information sharing.

By thinking of the problem as a DCog issue, several possible avenues of future work and interpretation open up, some of which we expand on in the following sections. The most obvious space for future work is to look at the role of ticketing systems in supporting the DCog activities around phishing management. These tools were heavily used by staff, but didn't provide an easy way to do things like give everyone access to the full set of phishing reports, or allow for easy highlighting of evidence. Other tools, like the lists of known compromised accounts, were kept separate from the ticketing system making it easier for some teams to miss information, leading inter-team friction.

Phishing is also an interesting DCog issue because of its frequency. Other work on DCog with system administrators [46] talks about how they regularly have to solve a wide variety of issues. Phishing is different in that it is a nearly daily occurrence and while the details of each attack vary, the processes needed to address it are far more stable. Which may mean that the types of support needed here can be more easily built into tools than the standard IT management DCog interactions.

7.2 The University wants reporting, but can it handle all the reports?

Everyone across the security community agrees that more phishing reporting is better [22, 79, 98] which is a view that was also shared by University staff as well as the University CISO. It is easy to see where this view comes from since staff reporting is the leading way to learn about security breaches [22]. Humans also have the nice feature that they are not deterministic, which makes their actions harder for attackers to predict and it also means that any sufficiently large campaign is likely to include several staff who are skilled at phishing detection, or just overly observant that day. Reporting phishing remains one of the best ways IS staff have of finding the attacks that are getting through the automated protections, so of course getting more such reports is important.

The problem though is scale. In order to be effective and identify all phishing that is getting through, all staff need to report any phishing they see. In theory this is a good practice, but it has the side effect of producing a very large number of reports which must be processed by someone. The need to manually process the reports is expensive in staff time. Currently, each report must be processed individually, even if they are bundled together, that still requires a human to individually select each report and then group them. This problem is one that is likely shared by all organisations that manage their phishing reporting through ticket tracking systems. With such a manual process, an obvious future work area is to look at potential automation or human support systems.

Unlike other service disruption type issues that help desks get reports about, phishing reports have a relatively high level of internal similarity. While phishing emails are designed to hide well in inboxes, they stand out as a group in the ticketing system due to the similar subject lines, report times, senders, and URLs. The University Help Desk already makes use of many of these features to manually group such emails. However, important information can also be overlooked due to the number of incoming reports. Phishing emails often have some amount of variance to avoid detection. A ticketing system doesn't have the tools necessary to identify which reports are the most important to look at because they exhibit different features. Reporting users may also be pointing out important information that staff do not have time to look at resulting in a lost opportunity to learn and improve technical defences [31]. For example, pointing out that the emails are still coming in through the filter.

We believe that it is impossible to fully automate the phishing report processing and incident management. Instead we recommend looking into ways to use automation to better support users in managing increasingly complex situations [6]. The use of automation can make the Help Desk's work more efficient while following the best practices [15, 101]. Help Desk staff could use support to better leverage their limited time. Their judgement is needed to both decide if the reported phishing is real [38], and to handle more specific questions users might have. One solution for the large number of reports is to automatically cluster a reports of similar phishing emails as a campaign (e.g. emails in Figure 1) and then based on those reports, the system would auto generate a detailed report about that campaign including the number of reports received and a list of reported compromised accounts. This potential solution can assist the Help Desk so they only need to label the first batch of reported phish and also decide if the escalation is necessary.

There is also some room to look at the effectiveness of AI conversational chatbots to look at the incoming user questions and automatically assign SS based on the question text. Chatbot use has been explored in SOC's to analyse and convey system alerts to security analysts [70] but have not yet been used to generate auto response to security incidents reported by users.

7.3 Ticketing tools support distributed cognition but have room for improvement

We observed the critical role played by the ticketing system in facilitating much of the inter-team collaboration. In this situation, the ticketing system itself can be considered an embodied agent with direct impact on the success of the distributed process [11] as it stores the phishing evidence, and it is how the different teams record what they are doing and communicate. It is also how the IRT team monitors what is going on so that they can maintain situational awareness and interject information when needed.

While inter-team collaboration seems reasonably well supported by the ticket tracking tool they use, there are still some potential areas for improvement and future research. In the case of phishing, teams need to see all the incoming reports associated with a campaign to accomplish two tasks: 1) tailor their mitigation to cover all the reported phishing variations, and 2) check if the mitigation has indeed stopped the attack. The second point also includes a need to see future incoming reports.

Ticketing systems are usually built around the standard information service model where a problem might happen, such as a power failure. While a service disruption results in many reports, they are basically identical in terms of information so only one report ever needs to be escalated. Phishing though has some differences because often users each receive a slightly different phishing email. So there is a need to be able to group reports together in a way that is visible to other teams.

Currently the Help Desk spends a great deal of time collecting together similar tickets manually, they also spend time curating tickets to make sure that the ticket they escalate has all the information later teams may need while the suggested solution supports the Help Desk goal to asses the impact of the campaign. An obvious improvement for the ticketing system would be to leverage the clustering idea to flag a representative number of reports with the features necessary for capturing variations within distinct campaigns. Such a system would save Help Desk time to find the variations, but it would also allow them to escalate in a way where the most useful reports are highlighted to other teams while also giving them visibility of the other reports, indicating the scale of problem. Flagging such information would provide teams with the contextual cues necessary for facilitating dialogues with other teams when further knowledge and resources are needed, aiding collaboration across the distinct systems. As a future research direction, it would also be interesting to investigate the contextual cues necessary for a range of incidents reported to help desk staff, and attempting to address limitations in current systems where break-downs in DCog prevent suitable incident response, not just regarding security incidents.

7.4 Best practice, is it helping?

The University made great efforts to align their structure and practices with industry best practice. They leaned heavily on a framework called ITIL, which provides best practices for IS service management designed to help organisations align practices with business needs. ITIL defines IS services from the customers' point of view to satisfy their needs and to bring value to them without ownership of risks [52]. It provides guidelines rather than rules as it determines "what should be done" as opposed to "how it should be done". Therefore, the implementation of ITIL is different between organisations.

ITIL identifies sets of activities, called processes, that respond to a specific trigger to accomplish specific objectives. The workflow discussed in this paper imply two main processes for handling phishing attacks, namely "Incident Management" and "Problem Management". Incidents are defined as an unplanned event to the service, such as the daily calls to the Help Desk (i.e. queue for printer help, password resets etc.) [52]. In our case, each phishing report, or request for guidance is an example of an incident. The same call can potentially evolve into a "problem" once the Help Desk receives several different calls regarding that specific attack, which in our case represents the individual phishing campaign. The calls are now considered more critical than the incidents as the impact to the system is greater than one off attacks; and thus, as discussed in Section 6.1.2, should be treated differently. However, given the difficulty in identifying repeating incidents [44] and the need for a quick reaction, current practices may allow for damage to occur when waiting for more phishing calls before escalation. Another method for triggering a problem should be considered when dealing with phishing to minimises the impact of incidents that cannot be prevented.

The studied University made an effort to develop an environment that encourages phishing reporting in line with guidance [67]. Much of this effort was dictated by ITIL, such as providing details for how to contact the Help Desk on their website, allowing users to contact them via several potential communication channels, providing customised feedback to users, and aiming to quickly resolve users' queries. The Security team also ran campaigns to educate staff and students about phishing and encourage them to report it. However, the number of phishing reports the Help Desk receives is relatively low considering the size of the University. Similar to previous research [10], we noticed some of the reports come to the Help Desk because reporters wanted help in determining the safety of an email, they already suspected that the sender was spoofed or that the email looked too sophisticated.

While prior research attempted to explore the effectiveness of ITIL in general IS operations [68, 73], our observations imply that the ITIL framework might not fully fit the workflow of phishing handling. Further research is needed to understand how organisations handle phishing while adhering to the ITIL framework and what barriers might arise from using such a framework.

8 Limitations

The case study may be suggestive of the situation of organisations but generalising the results requires further research. The case study looked at an academic institution that likely differs from other sectors. Universities also have a wide range of internal structures, so while this case is interesting and instructive, other Universities likely have different structures and may be impacted by things like their size and how centralised IT services are. However, we argue that many aspects of this case have similarities with other organisations; for example, using ticketing systems is quite common across sectors. We therefore believe that many of our high-level findings may be useful in future work around how to better support how IT handles phishing reports.

Both interviews and observations were used to collect data. While observations allow the researcher to observe work practices directly, interviews with participants are complimentary, gaining retrospective accounts of events that have happened across a wide time frame and validating observations made. That said, retrospective interviews are known to be somewhat biased towards memorable events such as particularly impactful phishing campaigns, which may have caused us to over-sample these events. Interviews also suffer from social desirability bias where participants may provide a version that does not fully reflect reality. To partially counter this issue, we asked every team about what they thought the other teams do and detail communication between them. We also attempted to provide validation of interviews through analysis of calls in the ticketing system. Due to limited access to the system and the use of other communication channels, we were not able to see all interactions between teams.

9 Conclusions

We explored the process of handling phishing incidents in a large University using a combination of interviews and observations. The University uses industry best practices aligned with ITIL to efficiently react to and prioritise incidents based on their potential impact. One observation is that large phishing campaigns can result in many reports which overwhelm Help Desk staff, making it challenging for them to respond individually to each report. We also find that the Help Desk operates as a kind of report triage, shielding third line staff, such as those that manage the email relays, from being inundated by reports that may not have the data they need to take action. Similar to earlier works [46], we also find that communication among staff in different teams is a key aspect of coordinating phishing attack mitigation. We also believe that managing phishing reports is an example of distributed cognition, where the different teams work together through the ticketing system to coordinate solving a multi-system problem. We believe that although it is impossible to fully automate phishing response, there is potential to better support IT staff through improved tools that allow them to handle the scale and complexity of phishing attacks.

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