Privacy-Enhancing Technologies in the Process of Data Privacy Compliance: An Educational Perspective

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Abstract

Achieving data privacy compliance presents a unique interdisciplinary challenge for experts from many backgrounds, particularly the technical and legal professions. As a potential solution for the legal mandate handed down by modern privacy regulations, Privacy-Enhancing Technologies (PETs) can serve as promising tools to help data processors demonstrate compliance. The implementation of PETs does not come immediately, however, and challenges in their adoption include their inherent technical complexity, as well as the lack of awareness and understanding of these technologies. In tackling these challenges, we investigate the educational needs of practitioners working in privacy compliance. Guided by Bloom's Revised Taxonomy, we begin the discussion on how the adoption of PETs can become more informed, with the goal of improving the efficiency and privacy consciousness of compliance programs. To accomplish this, we conduct 11 semi-structured interviews, analyze the results following Grounded Theory, and evaluate our findings in a survey with 24 respondents.

Keywords

Data privacy, privacy compliance, privacy-enhancing technologies, continuous education

1. Introduction

In a world where vast amounts of data are being created and processed on a continual basis, the need for the responsible handling of such data has starkly risen. Along with increasing concerns regarding the protection of individuals' privacy, the pressure placed on practitioners to comply with relevant data privacy regulations such as the GDPR raises the stakes for data processors [1][2]. Ultimately, a technical response in the form of privacy preservation must be implemented in data-intensive systems, a complex task that is accompanied by multiple challenges [3].

Recently, the promise of Privacy-Enhancing Technologies (PETs) has saturated the academic sphere, engaging researchers to develop innovative technologies for data privacy protection. In essence, PETs encompass a range of technical approaches designed to protect the data of the individual, when this data is utilized for some purpose. Such technologies, while falling under the same class of *Privacy-Enhancing Technologies*, are highly diverse, particularly in their applicable use cases. One unifying aspect, though, is their inherent complexity, which has kept their practical adoption quite limited [4][5]. Nevertheless, data processors can benefit from the deployment of PETs as a means of protecting sensitive information while still allowing meaningful utilization of the data.

The road to widespread adoption of Privacy-Enhancing Technologies begins with the transition from PETs as a research topic to the dissemination of such knowledge to practitioners in the industry. However, essential questions then arise as to who constitutes the target audience, and what specific knowledge regarding PETs is required by practitioners. To identify the target

CIISR 2023: 3rd International Workshop on Current Information Security and Compliance Issues in Information Systems Research, co-located with the 18th International Conference on Wirtschaftsinformatik (WI 2023), September 18, 2023, Paderborn, Germany
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audience, we look to the process of privacy compliance, which centers around the implementation of appropriate technical measures for the safeguarding of personal data being processed in a system. Gürses and Del Alamo [6] and Klymenko et al. [5] have shown that this process is highly interdisciplinary, involving primarily experts of technical and legal backgrounds. These two types of roles, therefore, become the focus of our work. We argue that education on PETs should take into consideration the diversity of roles in the privacy compliance process, as differing roles have distinct backgrounds, responsibilities, concerns, and, as will be shown, different interests regarding familiarization with PETs.

In this work, we aim to investigate the educational needs of practitioners with respect to PETs, with the goal of empowering them to be competent users of PETs, as "computer scientists and particularly IT security experts with knowledge about privacy-enhancing technologies are increasingly needed" [7]. We define the following research questions:

[RQ1] How can learning goals for Privacy-Enhancing Technologies be defined?

[RQ2] How can these learning goals be mapped to the role-specific needs of practitioners involved in privacy compliance?

To answer these research questions, we draw upon existing educational frameworks, leveraging the resulting insights from industry interviews to augment educational thinking on PETs. The possible learning objectives with regards to Privacy-Enhancing Technologies are segmented according to the framework of Bloom's Revised Taxonomy [8] introduced by Krathwohl. Subsequently, we evaluate the identified objectives via the administration of surveys. From this, we propose a new way of thinking about education on PETs, particularly considering the background of the person in question.

2. Background

A key step towards ensuring compliance with the data privacy regulations comes with the requirement to implement technical measures to protect the privacy of individuals. In this respect becomes important the concept of Privacy-Enhancing Technologies (PETs), a class of technologies that "protect privacy by eliminating or reducing personal data or by preventing unnecessary and/or undesired processing of personal data, all without losing the functionality of the information system" [9]. The recent guidance by the Information Commissioner’s Office (ICO) provides a detailed discussion on some of the prominent PETs, such as Differential Privacy, Zero-Knowledge Proofs, and Secure Multi-Party Computation, and outlines how they can help organizations to achieve data privacy compliance [10].

Although such advanced PETs present concrete solutions for personal data protection and multiple real-world use case examples have been reported [11][12], they still remain predominantly in the academic sphere and are not widely adopted in practice [4][5]. Among the main reasons for this, is the complexity of these technologies, as well as the lack of awareness, knowledge, and education on them [3]. Therefore, the promotion of continuing education on topics related to data privacy and PETs can be considered crucial to the development of successful privacy compliance programs. While the presented recent reports [10][11][12] highlight the significance of PETs and play an important role in promoting their implementation in the industry, these works offer a rather broader overview and do not focus on providing tailored and comprehensive educational content.

In this work, we consider the inherently interdisciplinary nature of privacy compliance and investigate the educational needs of practitioners based on the different roles involved in the process of privacy compliance, as proposed by Klymenko et al. [5]. Namely, the roles are divided into three categories: 1) *Legal* – practicing lawyers, specializing in the fields of privacy and data protection, 2) *Technical* – roles involved in the implementation of the product, such as software developers, engineers, and architects, as well as the appropriate management roles, and 3) *Go-Betweens* – practitioners working at the intersection of technical and legal fields, including roles such as Data Protection Officer (DPO), and Privacy Engineer.

3. Methodology

To assess the educational needs of practitioners in learning about PETs, we designed the interview and survey studies to focus on extracting the *learning goals* of the questioned experts. In the interview, this was done in a semi-structured way, with two categories of questions: background questions, including the interviewee's baseline knowledge of PETs, and questions aimed at identifying what kind of information about PETs is most relevant to the interviewee's role and responsibilities. A thematic content analysis according to Braun and Clarke [13] was conducted on the interview transcripts. The main goal of this analysis was to identify overarching themes expressed in the interviews, particularly relating to the learning needs and goals of practitioners with respect to PETs. Guided by following Grounded Theory (GT) Methodology [14], we analyzed interview transcripts concurrently to data collection and highlighted key themes, which were categorized into learning goals and educational needs. Axial coding was applied to identify relationships between these themes, supported by Bloom's Revised Taxonomy.

Based on the resulting learning goals identified by our analysis and introduced in Table 3, the survey statements were designed to map learning goals to role-specific educational needs, where each statement corresponded to a cognitive process in Bloom's Revised Taxonomy. The survey participants were then prompted to select the statement which best reflects their personal learning goals, allowing for the mapping of roles to levels in Bloom's Revised Taxonomy.

Table 1 and Table 2 present relevant information on the interviewees and survey participants. *Area* identifies whether the survey respondents are working in a technical (T), legal (L), or Go-Between (G) role. *Exp.* represents years of relevant experience. To mitigate bias, no survey respondents also took part in the interview study.

Table 1
Interview study participants

ID	Role	Area	Exp.	Sector
IP01	Product Owner	T	5	Machinery
IP02	CSO / Co-Founder	T	2	Software Development
IP03	System Administrator	T	2	Electronics Manufacturing
IP04	Trainee IT Strategy	T	1	Automotive
IP05	IAM Architect	T	6	Electronics Manufacturing
IP06	Solution Architect	T	5	Machinery
IP07	CTO, Co-Founder	T	4	Software Development
IP08	GDPR Senior Data Privacy Ambassador	G	33	Health Services
IP09	Developer, Owner	T	8	Software Development
IP010	Head, Applied Privacy Technologies Group	T	10	IT Services
IP11	Researcher, Applied Privacy Technologies Group	T	5	IT Services

4. PETs and Bloom's Revised Taxonomy

To formulate and categorize the learning goals of practitioners regarding PETs, we employ Bloom's Revised Taxonomy [8]. This taxonomy provides an organizational structure of educational objectives, consisting of the *Knowledge Dimension* and the *Cognitive Process Dimension*. The types of knowledge are structured into four categories: *Factual*, *Conceptual*, *Procedural*, and *Metacognitive*. These knowledge levels are mapped back to the six cognitive processes: *Remember*, *Understand*, *Apply*, *Analyze*, *Evaluate*, and *Create*. The knowledge levels are introduced below in light of PETs, and the resulting learning goal statements are presented in Table 3, which maps statements to their corresponding knowledge level and cognitive process. This mapping becomes relevant to understanding the role-specific learning goals of practitioners on the topic of PETs.

Table 2
Survey study participants

ID	Role	Area	Exp.	Sector
SP01	External Consultant (Law)	L	3-5	Health services
SP02	Developer	T	<3	Health services
SP03	Developer	T	3-5	Engineering
SP04	Developer	T	<3	Financial services
SP05	Developer	T	<3	Engineering
SP06	Legal Counsel	L	5-10	Financial services
SP07	Project Owner	T	<3	Media
SP08	Architect	T	3-5	Engineering
SP09	Data Protection Officer	G	5-10	Construction
SP010	Developer	T	<3	N/A
SP11	Developer	T	3-5	Engineering
SP12	Management	T	3-5	Financial service
SP13	Privacy Engineer	G	3-5	Public service
SP14	Compliance Officer	L	<3	N/A
SP15	Legal Counsel	L	<3	Financial services
SP16	External Consultant (Law)	L	5-10	N/A
SP17	Project Manager	T	<3	Financial services
SP18	Developer	T	<3	Financial services
SP19	Project Manager	T	10-20	Engineering
SP20	Architect	T	5-10	Education
SP21	Privacy Engineer	G	<3	Education
SP22	Legal Counsel	L	5-10	Public service
SP23	IT Architect	T	10-20	Public service
SP24	Management	T	20+	Media

4.1. Factual Knowledge

Factual knowledge includes terminology, characteristics, and features of PETs. The simplest learning goals are to list different PETs, as well as to know about the use cases of PETs, a topic most directly corresponding to *Remember*. Analyzing PETs on a factual level can be conceived as comparing different PETs and accordingly selecting technologies. It thus becomes clear that the tasks build up on each other, i.e., that *Remember*, *Understand*, and *Apply* are required to perform the subsequent *Analyze* tasks.

4.2. Conceptual Knowledge

Conceptual knowledge is closely related to theoretical topics, such as introducing models, approaches, and interrelations of PETs. As opposed to factual knowledge, conceptual knowledge includes the principles behind the functionality of PETs. Based on the study results, statements are focused on system architecture, as interview participants reported a need to understand this topic better. The idea of integrating newly learned information into existing knowledge domains characterizes conceptual knowledge. However, it encapsulates the decision over which technology would be applicable; the implementation itself belongs strictly to the following category.

4.3. Procedural Knowledge

Here, the focus is placed on the implementation of PETs. Although the statements presented are expected to be universally applicable to all privacy roles, there is now a shift towards more technical content. Applying Procedural Knowledge marks the point where the learning content becomes rather technical, implying that a higher level of technical literacy is required. Furthermore, it shows how many learning goals can be identified before implementation. The next modification of the cognitive category is directed at the implementation action itself. The intent is not just to implement PETs in any fashion but to know parameters and quality measures, and thereby build an implementation strategy. Ultimately, the goal of procedural knowledge is not only to find the most suitable PET, but also to contribute to the development of new PETs.

4.4. Metacognitive Knowledge

Privacy-Enhancing Technologies are under constant pressure to evolve, as are any technologies employed to minimize risks or mitigate threats. The question of maturity is of great interest with Privacy-Enhancing Technologies. Achieving such knowledge requires a deep knowledge of the PETs in question, the environment in which PETs are implemented, and awareness of the limitations of the technologies. Therefore, learning goals in this knowledge category convey this critical approach, while also focusing on finding strategies to address these limitations. The highest learning goal would be to transfer knowledge to formerly unknown domains, identifying new purposes for PETs.

4.5. Learning Goal Statements

Table 3 presents the set of learning goal statements for PETs, which is based on Bloom's Revised Taxonomy and supported by the interview findings. Using the guidelines provided by the original taxonomy and augmenting these with goals expressed by interviewees, we build the statements in Table 3 to align with the knowledge levels and cognitive processes of Bloom's Revised Taxonomy. This mapping process is aided by Anderson and Krathwohl [15] and inspired by Servin et al. [16], the latter of which extends existing verb sets to include the technical domain.

Table 3
Learning goal statements based on Bloom's Revised Taxonomy

	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge	I want to know what different PETs exist.	I want to know the various use cases for PETs.	I want to be able to follow discussions about PETs.	I want to be able to differentiate PETs.	I want to verify statements about the features of PETs.	I want to be able to classify a new PET.
Conceptual Knowledge	I want to know how and why PETs work.	I want to know how PETs are integrated into a system architecture.	I want to be able to create my own architectures involving PETs.	I want to be able to compare PETs based on their principal attributes.	I want to decide on which PET would be most suitable in a given system environment.	I want to create meta-models for PETs.
Procedural Knowledge	I want to identify use cases for applying PETs.	I want to be able to explain how different PETs are implemented.	I want to be able to implement PETs in a system environment.	I want to compare different ways to implement PETs.	I want to decide on the best way to implement a PET in a given situation.	I want to contribute to the development of new PETs.
Metacognitive Knowledge	I want to know the limitations of PETs.	I want to identify the limitations of a given PET implementation.	I want to be able to give strategies for optimizing the implementation of PETs.	I want to compare PET implementati ons based on their effectiveness.	I want to evaluate PET implementations and develop recommendations.	I want to find new use cases to which PETs could be applied.

Table 4
Survey answers per privacy role category

(a) Technical Experts

	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge	15	14	8	3	2	0
Conceptual Knowledge	15	12	11	6	4	0
Procedural Knowledge	15	13	11	7	7	0
Metacognitive Knowledge	15	12	8	2	2	2

(b) Legal Experts

	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge	6	4	4	4	4	2
Conceptual Knowledge	6	3	2	2	2	0
Procedural Knowledge	6	3	2	2	2	0
Metacognitive Knowledge	6	4	3	3	1	1

(c) Go-Betweens

	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge	3	3	1	1	1	1
Conceptual Knowledge	3	3	2	2	2	1
Procedural Knowledge	3	2	0	0	0	0
Metacognitive Knowledge	3	2	2	2	1	1

5. Role-Specific Educational Needs

To evaluate the relevance of the presented in Table 3 learning goals for different roles, we conducted a survey with practitioners. In designing the survey, we first ensured that the role of each respondent was captured. Next, the statements of each separate knowledge level were presented, and the respondent was prompted to select which statement was most relevant to the task of their specific privacy role. In addition, the respondent was informed that the statements followed a hierarchical order, meaning that selecting a more advanced cognitive process included all the previous ones as relevant. For example, in the Factual Knowledge category, choosing "I want to know the various use cases for PETs" implies that "I want to know what different PETs exist" also applies.

The role-specific insights are presented in Table 4 which separates the results based on the reported role. Table 4 utilizes a heat map to illustrate the frequency by which a particular option was chosen. Thus, the number displayed in each cell represents the aggregated number of responses that the corresponding option received, considering the previously introduced hierarchical setup.

As can be seen from Table 4, roles from the three different privacy role categories possess different learning goals, which is made particularly salient by our utilization of Bloom's Revised Taxonomy. Table 4b suggests that legal experts in the privacy compliance process would be most concerned with obtaining factual knowledge about PETs. This is plausible, as legal experts would not be involved in the implementation of PETs, but rather must be knowledgeable on the topic in general, i.e., know the facts. In Table 4a, a clear preference from technical experts towards factual and procedural knowledge can be observed. Thus, these experts must not only be cognizant of the facts, but also be skilled in the procedural know-how required for the implementation of PETs. Another interesting finding arrives with an analysis of the learning goals of Go-Between roles, whose preferences seemingly reside distinctly in conceptual knowledge. Looking to Table 3 for an explanation, one can see that conceptual knowledge truly lies on the border between factual and procedural knowledge, in the way that factual knowledge becomes important more from an IT architecture and policy point of view, rather than pure implementation. Indeed, members of the Go-Between category do exist to bridge this gap, serving as a crucial link between legal mandate and technical specification.

6. Conclusion and Outlook

In this research in progress, we explore the educational needs of privacy professionals with respect to learning about Privacy-Enhancing Technologies. Under the framework of Bloom's Revised Taxonomy, we subdivide PET education into learning goals based on six cognitive processes and four knowledge levels. Moreover, we probe the relevance of each of these categories with different subgroups of privacy professionals: technical and legal experts, as well as Go-Betweens. The results of the survey provide insights into differing educational needs governed by the requirements of each role.

The practical relevance of this work is grounded in the underlying complexities of state-of-the-art PETs, which, without the necessary expertise, can hinder their adoption, calling for focused educational efforts to foster the development of such expertise. Looking forward, we plan not only to continue working on making knowledge on PETs open, accessible, and understandable, but also to do so in a way that considers the expertise of the learner. Our next steps include the creation of learning material on PETs, the validation of such material, and the deployment of an e-learning platform to encapsulate the learning content. In the creation of learning material, the findings presented in this work will be integral to tailoring the learning experience to different professional backgrounds with specific learning needs. The e-learning platform will provide the opportunity for collaboration with industry partners, further closing the gap between academia and industry on the topic of Privacy-Enhancing Technologies.

Acknowledgements

This work has been supported by the German Federal Ministry of Education and Research (BMBF) Software Campus grant LACE 01IS17049.

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