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Development of ICT Infrastructure Management Services for Optimization of Administration of Educational Institution Activities by Using ITIL-v4

Dalė DZEMYDIENĖ[1], Sigita TURSKIENĖ[1], Irma ŠILEIKIENĖ[1,2]

[1]Institute of Regional Development Šiauliai Academy Vilnius University, Vilniaus str. 88, LT-76285 Šiauliai, Lithuania
[2]Department of Information Technologies Faculty of Fundamental Sciences Vilnius Gediminas Technical University -Vilnius Tech, Saulėtekio ave. 11, Vilnius, Lithuania

dale.dzemydiene@mif.vu.lt, sigita.turskiene@sa.vu.lt, irma.sileikiene@vilniustech.lt

ORCID.org/0000-0003-1646-2720, ORCID.org/0000-0002-2019-6712, ORCID.org/0000-0002-1185-0970

Abstract. The services for information communication technology (ICT) infrastructure management (i.e., ICT strategy creation, ICT configuration, ICT incidence management, re-engineering) have become an increasingly important and complex processes in nowadays works and as well as in recent educational institutions. The pursuit of the effectiveness of ICT infrastructure management services and the ability to convey information of various profiles in the work of educational institutions requires a wide range of non-homogeneous ICT infrastructure management changes. The article examines the development possibilities of ICT management methodology and service provision tools, which become significant in the work of administration of ICT infrastructure of the educational institution. The application of the proposed methodology ITIL v4 forms a new understanding of value acquired through ICT infrastructure development. An approach of creation of ICT infrastructure and ITIL library was developed and helps in service management processes by having an impact on the training of ICT infrastructure management specialists and the maintaining of the entire ICT infrastructure. An approach includes the inter-operability of using of appropriate computerized, cloud-based systems like National Registers, LITNET online IS, "FreshDesk", etc., which are used for ICT administration processes. The case study under consideration covers the management of the infrastructure of the ICT sector of the secondary education institution, starting with the improvement of the communication network infrastructure, and enabling the specialized development and management of incident management and content delivery tools. The results of ITIL v4 methodology implementation were illustrated by providing the detection and elimination of ICT incidents. The usage of some software packages for automatization of ICT management services as "FreshDesk", LITNET online IS are demonstrated on real working ICT infrastructure of the typical educational institution.

Keywords: information technology infrastructure library (ITIL), information communication technology (ICT); ICT management software, education institution.

1. Introduction

The processes of delivery of e-content for proper execution of institutional services and the implementation of ICT infrastructure for ensuring the proper execution of all organizational management processes are very important in nowadays institutions. The possibilities to apply the upcoming new ICTs form new challenges for the management of complex infrastructure of organization. Certain types of problems have to be solved when the capacity of a certain ICT chain begins to fail, there are threats of cyber vulnerabilities, or the risks arise when we deal with power supply disruptions or other malfunctions. Promoting the effectiveness of ICT management services and managing various information transfer opportunities is gaining more and more importance in the work of institutions (Smale et al., 2023; Dzemydienė et al., 2022a; Dzemydienė et al., 2022b). However, in the work of secondary education institutions, insufficient attention is paid for the operational solutions to ICT service management problems, optimization of the use of internal resources, while there are a wide variety of different frameworks and initiatives for description, management and control of ICT processes in the market (Spohrer and Maglio, 2010).

The development possibilities of ICT service management methods and tools are examined in this article by analysing their significance after the expansion of the ICT service spectrum changing processes in the management and administration processes of the educational institution. The choice of appropriate ICT service management tools affects the quality of the whole organization's activities.

The systems of rules and methods, including the examples of good practices, explain how important is the carrying out process of correctly maintaining of the ICT special functions. But each of them analyses the situation in different aspects. For example, several models of information technology infrastructure library (ITIL) management with recommendations of COBIT (Gordona, 2021), and with Capability Maturity Model Integration (CMMI) possibilities can be applied. The basis of ITIL realization and integration with right methods, which can be used in the institution the ICT specialists have to execute and maintain correctly the services of organization like: management of incidents and ICT disturbances, management of long-term problems (reasons of incidents), maintenance of corresponding documentation, management of introduction of new services or changes in the existing services, seeking to optimize main work processes, and solve related problems.

Other ICT management methodologies, like SCRUM, Agile, DevOps, Lean are integrated in the ITIL v4 methodology infrastructure, and enable the process of ICT infrastructure service management to be more appropriately structured and specified. The ITIL v4 methodology is not widely used in organizations, and the seeking of effective managing processes of ICT services and ensuring of the highest possible quality of the providing ICT infrastructure are very important. ITIL v4 defines a new understanding of service value in the context of ICT infrastructure management (AXELOS Limited, 2020).

New ICT fundamentally changes are not only the activities of state and self-governing of institutions, but also creates prerequisites of educational institutions for improving of the quality and productivity of the service provision, enabling the increasing of the effectiveness of management, and ensuring the transparency of activities in the entire education sector. Government institutions, educational institutions that have transferred administration services to e-mail, internet space, consuming of minimized financial resources are related with these types of services (Ginevičius et al., 2006).

Innovative ICT, such as service-oriented architecture, cloud technologies, application of templated scenarios, creation of open data access, provides opportunities for more intensive development of data exchange and reuse of data and increases the efficiency of services. The legal acts of the Republic of Lithuania and the directives of the European Union (EU) oblige to move to more effective forms of digitization and integrative possibilities of information systems (IS) (Lithuania's Progress Strategy "Lithuania 2030", 2012).

The legal and technical base in the public sector is sufficiently prepared, harmonized and meets EU requirements and standards for the use of official systems (Lithuania's Progress Strategy "Lithuania 2030", 2012). However, educational institutions are still hesitant to move to the innovations and opportunities of innovative tools. There is a sense of digital differentiation in the use of administrative tools. There is a lack of an integrated, coordinated approaches, which can enable the adaptable application of information resources, their implementation in the infrastructure of educational institutions at all levels.

The specificity of the management of educational institutions means that employees of all levels share the coordination of management, working groups and activity planning. Participating at each level, the main customers - teachers, middle managers, managers - are interested persons who strive for the implementation of common goals, and their work principles are transferred to the operational processes of information systems (IS) that enable the development of automated systems. The benefits of ICT management in education have implications for better collaboration between the school as an administrative unit, parents and external institutions and local authorities. The management of ICT services influences the productivity and efficiency of the work of an organization, company or institution, the dependence on paper documents decreases, an organized information and service transmission system is created, which takes into account the needs of the institution (DESI, 2022). Institutions that do not implement ICT service management innovations have risk for losing of the ability to effectively manage complex processes.

The aim of this research is forwarded for development of approach of implementation of ITIL-v4 methods for analysis and maintaining of the infrastructure of ICT of educational institution. The objectives of this research are concerning the development of constructional structure of description of activities of educational institution for developing of ICT library following to requirements of the ITIL-v4 methodology. The set of recommendations are provided for analysis of ICT infrastructure management services by showing more possibilities of modern ITIL v4 methodology application tools. The objectives are realized by showing the possibilities through the solving some problems of ICT service management according to detecting of ICT incidents and realizing them. The results are related to the development of ICT functional capabilities for the modernization of the work of secondary education institution, by demonstrating the advantages of ICT management services. The results of experimental research enable to provide recommendations for selection of ICT infrastructure management tools and demonstrate their functional advantages. The experimental results with additional forms of integrated information systems (IS) helps to form a new understanding of value acquired through ICT infrastructure development and services efficiency. The article describes how the development possibilities of ICT management services are accesses, and how it is possible to implement by the certain methodology and tools, which become significant in the works of educational institution. The implementation strategy of methodology of ITIL v4 is

recommended for the application for ICT infrastructure management services by realizing optimization of administrative processes in the educational institution.

2. Initiatives for promoting of ICT development

The goals for the development and implementation of necessary digital infrastructure of organizations for seeking of ICT innovativeness and new development tools are formulated in the EU Digitalization Development Strategy until 2030 (Lithuania's Progress Strategy "Lithuania 2030", 2012). The EU becomes an example of a society to which ICT provides more opportunities in EU Data Strategy (COM/2020/66 final). The quality of ICT development and the development and implementation of information management systems depends on the methods of activity organization, production management, consumption and lifestyle habits. Access to information systems and the ability to use innovative ICT are extremely important for innovation and rational growth. ICT infrastructure developed means and innovative management systems bring all sorts of benefits to citizens and the economy, help to improve e-public services in the European Data Strategy (COM/2020/66 final).

The main goal of the strategy for the implementation of ICT in education is to foresee the perspective and directions of the integration of ICT at all levels into Lithuanian general education and to plan the steps of its implementation, to help harmonize the work of various institutions and to effectively use the funds allocated for the computerization of education (Lithuania's Progress Strategy "Lithuania 2030", 2012).

The implementation of ICT in Lithuanian state general education schools started already in 1986, starting with teaching the basics of informatics and computing techniques, with the aim of centrally equipping schools with computers and creating favourable conditions for teaching informatics (Ališauskas et al., 2000). The Centre for Educational Information Technologies is now responsible for formulating the policy of ICT implementation in Lithuanian general education schools. In the absence of a long-term and comprehensive strategy for the implementation of ICT in education, the influence of this Centre on the computerization of education was limited, and there was a lack of harmony between the general information technology integration regulations published by the state and the work carried out by lower management chains.

In the laws regulating the organization and management of the education system, the mission of county education centres and district education departments when implementing ICT in schools is not directly named. However, the influence of these institutions is significant and important: county educational and regional computer centres organize qualification improvement events, allocate funds for the purchase of computer equipment and software. The policy of implementing ICT in education is formed by the instructions of management institutions and school communities (COM/2021/750 final). How the ICT infrastructure and ISs will be used and developed depends on the school's activity, attitudes and decisions, how information about modern technologies will be disseminated, how much and what kind of support can be obtained for the implementation of school modernization projects. Computer science teachers, school librarians, and administration play an important role in determining the priorities of ICT implementation at a school. The development of reliable technologies enables new developments for an open and democratic society, a vibrant and sustainable economy. Digital solutions are also crucial in the fight against climate change and the transition to a green economy. The EU's

digital strategy states that investments will be made in the digital competences of the entire population. Measures are being developed to increase protection against cyber threats (hacking, ransomware, e-identity theft) and to ensure the artificial intelligence (AI) systems for developed in a way that respects human rights and earned trust. It is especially relevant to accelerate the implementation of ultra-fast broadband when implementing ICT. Anticipated development actions, developing the capabilities of supercomputers, will require transformations that will affect the implementation of innovative solutions and accelerate a fair and competitive digital economy. The challenges of strategic digitization touch on measures to strengthen capacities in data management, artificial intelligence and advanced technologies. In the EU, digital sovereignty will depend on the ability to store, access and process data, respecting the requirements of trust, cybersecurity and fundamental rights. Digital economy, data processing, cloud computing and networks development became objective for educational institutions.

3. ITIL-v4 framework overview

The analysis of ITIL framework applications shows that it is the most usable for ICT service management practice for more than 30 years. ITIL is a framework for providing IT service management (ITSM) that consists of best practices and processes that may be implemented. The ITIL 2011 v3 framework is used to manage IT services effectively throughout the five phases of the IT service lifecycle: strategy, design, transition, operations, and continual improvement. The ITIL v3 framework focuses on the service lifecycle functions and processes that help implement or improve IT services.

ITIL 4 presents holistic approach which raises the profile of service management in organizations, setting it within a more strategic context. The ITIL v4 framework focus tends to be on end-to-end product and service management, from demand to value. The key components of the ITIL 4 framework are the ITIL service value system (SVS) and the four dimension model (AXELOS Limited, 2019).

New version of IT management methodology, i.e., ITIL-v 4 brings the ITIL up to date by re-shaping much of the established of ITSM practices in the wider context of customer experiences, value streams, and digital transformation, as well as embracing new ways of working, such as integrating in the whole methodology elements of Lean, Agile, and DevOps methods (AXELOS Limited, 2019), ITIL-v4 can improve IT service quality, reduction of service provision costs and improve satisfaction of users (Orta, Ruiz, 2019). Analysing how organizations can improve their performance, one of the areas for improvement may be the application of effective methods and solutions for delivering and supporting IT services. The first step is to define what service management is. Service management is a set of specialized organizational capabilities for enabling value for customers in the form of services. This means that service management requires the definition of the entire infrastructure, with detailed tools and resources that are used for creation, maintaining and provision of services provided. The ITIL-v4 framework defines the function by implementing the 4-th dimensional service management structure: ICT service management value for infrastructure of organization and people, value for more optimal application of ICT infrastructure, value for partners and suppliers, value for streams and processes of works.

It is important to note, that the four dimensions of service management we can apply to all services being managed, as well as to the service value system (SVS) in general. It

is therefore essential that these perspectives should be considered for every service, and that each one should be addressed when managing and improving the SVS at all levels (AXELOS Limited, 2019).

The key components of the ITIL-v4 framework are the ITIL SVS and the four-dimensional model, related with the various components and activities of the organization enabling to work together and to facilitate value creation through ICT enabling services. This is understood as the focusing of an organization's internal and external resources and processes on the service value chain with concretely formulated guiding principles, governance, and organize continual improvements. The central element of the SVS is the service value chain, the operating models, which are outlined as the key activities, which are required to respond to demand and facilitate value realization through the creation and management of products and services (AXELOS Limited, 2019). The ITIL service value chain includes six value chain activities, which are leading to the creation of products and services: planning, continuing improving, and engaging of ICT, design of ICT configuration and transition information about changes, obtaining/building of structures and integration with interrelated information systems and registers, delivering and support ICT management services.

Education is a core service provided by educational organizations, where IT services represent only a fraction of the post-pandemic education service, and educational institutions are increasingly using IT resources to increase the accessibility of education services and to create modern learning content. An iterative service design tree is proposed, as shown in Figure 1. It allows for a complex analysis and design of the service model to ensure a higher value and quality of the service created. This technique is a part of the Kanban method and works well in environments where the throughput (intake of work) is predictable (AXELOS Limited, 2020).

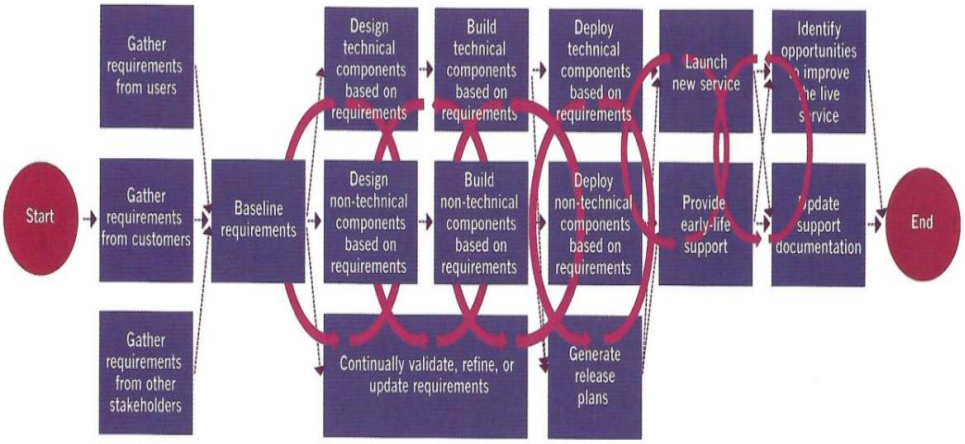

Figure 1. Representation of complexity of service value streams in organization (Source: AXELOS Limited, 2020, p. 63)

Therefore, the application of ITIL good practices to support and improve the quality of education services is a timely solution that can bring about a qualitative breakthrough in education services, responding to the learning needs and styles of today's generation of

youth. The ITIL v4 framework provides a model of the value stream as a new service or product created for customers. The simply way is shown in some stages of gathering the requirements, design new service, the creation of new services, and launching to new service (AXELOS Limited, 2020).

ITIL-v4 describes service configuration management practices that help ensure that accurate and reliable information about the configuration of services and the configuration items (CIs) that support them is available when and where it is needed. This includes information on how CIs are configured and their interrelationships. Configuration item (CI) is any component that needs to be managed in order to deliver by the IT service management process. Service configuration management collects and manages information about a wide variety of CIs, typically including hardware, software, networks, buildings, people, suppliers, and documentation. Services are also treated as CIs, and configuration management helps the organization to understand how the many CIs that contribute to each service work together.

The CIs that contribute to each service and their relationships: how they interact, relate, and depend on each other to create value for users. This includes information about dependencies between services. This high-level view is often called a service map or service model, and is part of the service architecture. Configuration information can be stored and published in a single configuration management database (CMDB) for the whole organization, but it is more common for it to be distributed across several sources (AXELOS Limited, 2019).

Configuration management typically needs processes to:

- identify new CIs, and add them to the CMS;
- update configuration data when changes are deployed;
- verify that configuration records are correct;
- audit applications and infrastructure to identify any that are not documented.

Creating and maintaining an up-to-date configuration database is a major challenge for any organization due to the size of the IT infrastructure, which is well developed with many CIs. Collecting information on all CIs is a time-consuming task, as the larger the organization, the larger the IT infrastructure, the more CIs. Therefore, often the CMDB only stores information about certain CIs that are important for the organization, such as servers, software licenses, etc. Thus, the IT infrastructure data at the operational level of the CMDB is sufficient for day-to-day support "Service Desk" work, but insufficient for strategic infrastructure monitoring and management.

"Service Desk" should be the entry point and single point of contact for the service provider with all of its users. Service desks provide a clear path for users to report issues, queries, and requests, and have them acknowledged, classified, owned, and actioned (Jois, Pallassena, Chakrabarti, 2020). An efficient "Service Desk" requires specialized hardware and software to support the "Service Desk" process, such as:

- intelligent telephony systems, incorporating computer-telephony integration, IVR, and automatic call distribution;
- workflow systems for routing and escalation;
- workforce management and resource planning systems;
- a knowledge base;
- call recording and quality control;
- remote access tools;
- dashboard and monitoring tools;

- configuration management systems.

When choosing “Service Desk” or “FreshDesk” software packages, it is important to look at the above technologies as tools for analysing the functionality of the software, deciding what is relevant and necessary in a particular case and what may not be relevant. This should determine which software should be chosen in a given case.

4. Examples of application of ITIL-v4 methodology in management of ICT infrastructure services

ITIL v4 methodology in ICT infrastructure service management of educational institutions can be especially valuable for ICT engineers (Price, 2019). The ITIL application methodology helps to manage ICT infrastructure components, coordinate them with each other, divide incidents and service requests into certain categories. Incidents are defined as unplanned interruptions of ICT services or degradation of service quality (AXELOS Limited, 2020). Incident management is not the same as a simple customer service request. A service request may be related to security, facilities management, fleet reservation, facility requirements or asset management monitoring. Reporting an incident is usually something more urgent than, say, a request for an assessment of the need for a particular piece of equipment. An incident is an event that has a negative impact on the quality of ICT services provided, i.e. ICT services become unavailable or are provided at a lower than agreed quality level. It may be a computer network failure that limits the ability to use electronic services. Such as the unavailability of the learning environment during classes. Some incidents may cause disruptions in the teaching process.

ICT service centres can improve the provision of activities. Most educational institutions are moving to a shared service environment management infrastructure to manage incidents and inefficiencies in a unified manner. Automated tools for ICT management services provide visibility into the performance of operations and allow for a higher level of documentation of service delivery while reducing the number of incidents.

Service management also allows users to perform self-service actions. Using self-service technologies, employees can find solutions to service failures before contacting the service centre. The implementation of ICT service functions and their automation reduces the workload of the service centre analysts.

Most educational institutions use service management technologies to share information and solution sets with users. This technology means that service centre users can collaborate, share data and information directly (Price, 2019). In a world where the expectation is always to receive the right ICT infrastructure support services, it is important to have a quick and easy incident management process. The goal of incident management practices is to minimize the negative impact of incidents by restoring normal service operations as quickly as possible.

One of the examples of the choice of software is the "FreshDesk" software package, which enables the formation of an ICT service management and operations team and response actions to unplanned events, service disruptions, in order to restore the service.

In the system, the incident must be registered and handled in such a way that it is resolved within a time that meets the expectations of the customer and the user. Incident resolution times are agreed, documented and communicated to ensure expectations are realistic. Incidents are prioritized based on an agreed classification to ensure that incidents

with the greatest operational impact are resolved first. Organizations should develop their own incident management practices, appropriate governance and resource allocation to manage different types of incidents. Low impact incidents must be managed effectively to ensure that resources are not consumed. Higher impact incidents may require more resources and more complex management. There are usually separate processes for managing major incidents and managing information security incidents. Incident information should be stored in incident records using the appropriate tool. Ideally, this tool should also provide links to related changes, issues, known bugs, and other knowledge that allows for quick and efficient incident diagnosis and recovery.

Modern ICT infrastructure service management tools can provide automated incident management and provide intelligent incident data analysis to make recommendations to help future incidents.

It is important that the people working on the incident provide timely information updates. These updates should include information about disruptions, business impact, areas affected by the incident, completed actions, and planned actions. Each of these components should have a timestamp and information about the people involved so that they can be kept up to date. Collaboration tools may also be needed so that people working on an incident can collaborate effectively.

Incidents can be identified and resolved by different groups of people depending on the complexity of the problem or the type of incident. All these groups must understand the incident management process and carry out the activities assigned to them, as this helps to manage service value, results performance, cost and risk:

- Some incidents can be resolved by users themselves using self-help. Specific self-help records should be captured for use.
- Some incidents can be resolved by the service department.

More complex incidents are usually transferred to the support team for further resolution. Typically, the resolution is based on the incident category, which should help identify the appropriate resolution for the incident.

The incident may be forwarded to suppliers or partners who offer their support, products and services.

For the most complex incidents and all major incidents, a problem management process is initiated, which is responsible for the detailed investigation of the incident and the search for possible solutions. An issue management team can include representatives from multiple stakeholders, including the service provider, suppliers, users, and more.

In some extreme cases, recovery plans may be used to resolve the issue.

Effective incident management often requires a high level of collaboration between team members or individual teams. These teams may include service desk, technical support, application support specialists, ICT suppliers. Collaboration can facilitate documentation process, information sharing and help in the resolving of the incidents more effectively.

Some organizations use a technique called "swarming" to help manage incidents. It involves many different stakeholders initially working together until it is clear which one is best suited to continue the task and which can move on to other tasks.

The package “FreshDesk” provides a formalized incident recording and management process. This process includes detailed diagnostic, investigation, and incident resolution procedures, and can provide more efficient methods of investigation and failure detection. These can be scripts to collect information from users, initial contact details that facilitate the resolution of simple incidents. Investigating more complex incidents often requires

expert knowledge. Priority is given to assessing both the frequency and severity of incidents:

Incident management requires regular communication between ICT service providers and users to understand failures, set expectations, provide status updates and communicate which failure is being addressed or resolved and the incident resolved;

ICT configuration, design and transition to newer versions of infrastructure components are carried out, when trial versions are tested before new services are provided;

Anticipation and assessment of how to "get/create" new ICT services, so that during the transition to new technologies, reengineering issues do not cause disruptions to work activities, so that changes are planned in advance, incidents that occur are resolved in time and are controlled. The efforts are made to ensure that introducing innovations to employees and communicating change enables appropriate problem solving.

5. Development of ICT infrastructure of the organizational and administrative activities of the educational institution

The institution of empirical research is choosing the secondary school (i.e., gymnasium) that follows the activity model approved by the X city Municipal Council, which aims are to strengthen students in STEAM direction, i.e., the teaching is forwarded of subjects paying more attention in the field of natural sciences, technology, engineering, mathematics and the arts, and at the same time forming the value attitudes of students, applying elements of the concept of classical education. According to this model of STEAM education, the tasks of digitalization of all activities are implemented, which also includes accounting of teachers' wages and accounting of allocated funds, etc. tasks.

The structure of organizational and managerial activities of educational institution is quite complex and can be expressed by hierarchical tree model (Figure 2). All such activity requires the adequate development of ICT for realization of works and development process of whole the infrastructure of ICT became quite complex. All parts of these works are related interoperable and are coordinated by ICT specialists by stages of development, maintenance and re-engineering.

Tasks are related to planning are solved in a certain order:

- the number of relevant classes of the X educational institution for the school year is determined and coordinated with the decision of the Municipal Council;
- the number of full-time teacher-teachers and the need for expenses for their wages are evaluated in accordance with the procedure established by legislation, taking into account the number of classes formed and the number of hours allocated to the teaching of subjects per year (principles of calculation of full-time positions);
- targeted funds of the Municipality budget are planned in the Strategic Activity Plan of the Municipality for the salary of teachers-teachers, as needed for the improvement of the educational environment of the Gymnasium, for the purchase of learning tools for classes and are allocated to the Gymnasium in accordance with the procedure established by legislation.

Additional sources of funding can be EU structural funds, national and international educational programs, business companies and associations, Gymnasium support, etc.

The documentation of the educational institution is registered in the system "Avilys", with the help of registering and showing the set of documents, which are transferred to other educational institutions of the district or specialists of the city municipality. However, the vast majority of documents are paper-based and have not fully transitioned to e-document management systems.

Students are included in the national IS “Student register”. Student enrolment is computerized, but has its drawbacks. Student assessment is brought to e-diary system named "My diary", with the help of which certain communication activities of the institution's employees and students and their parents take place. Such a digital diary is a tool for monitoring student attendance.

The ICT infrastructure of the educational institution consists of many components, such as workplaces, work stations, personal computers, their access to computer networks by internet (INT), Computer networks of Local Access Area (LAN), wireless networks (Wi-Fi), servers and other systems, etc. (Table 1).

Faster access networks are used, such as the LITNET from the national internet service communication network providers. The wireless network functions - WAN, LAN, Internet Provisioning Functions (INT), other wireless network coverage technologies such as Wi-Fi, platforms for Internet interfaces with Registries of National Significance are provided. Other systems are used for whole infrastructure support:

- The system watt.lt – is national IS, as Register of civil servants and civil service management information system (VATARAS/VATIS),
- The maintain of interrelation with the administrative and public information systems and public e-service portals:
  - The system-portal of public e-services (e-paslaugos.lt),
  - The online system- Register of staff administration (pedagogai.emokykla.lt) that connects the register of pedagogues,
  - The Register of educational and scientific institutions - smir.smm.lt,
  - The platform of higher management functions - bvs.klaipeda.lt that has links with the strategic planning information system, etc.

By implementing the collaboration systems (such as SharePoint), the organization have the opportunity to create more value for the user by saving time and getting more prompt services. The proposed services would allow reducing the volume of paper documentation, transferring most of the data to information systems and saving time when information is repeated and needs to be separated according to the needs.

The management of ICT infrastructure services using the ITIL methodology creates an ever-increasing added value, as it enables faster work and increases the productivity of ICT infrastructure services. Any hardware, such as the purchase of a powerful server or data centre, requires proper planning steps and the ability to integrate interrelated software, to know the entire IT infrastructure and IT services. The right combination of price and reliability remains important.

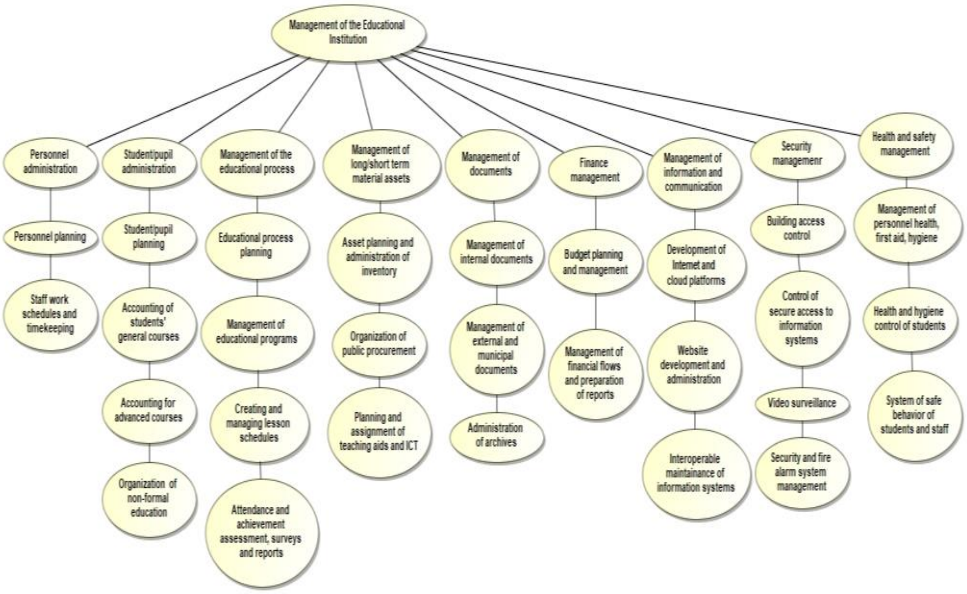

Figure 2. The illustration of organizational and managerial activities of X educational institution representing by hierarchical tree structure

The ICT infrastructure of a particular educational institution consists of various ICT components and products for provision of ICT services (Table 1) by following the supporting process of the detailed activity structure (Figure 2).

6. Results of incident management of the ICT infrastructure of the educational institution

There are some software packages which are prepared for managing of ICT infrastructure services. Systems like “JIRA”, “Service Desk”, “Help Desk”, “FreshDesk” can be mentioned. One of them is more easily adaptable system – “FreshDesk”. It allows the assignment of agent roles and the creation of incident handling groups, chat support, e-mails. Message forwarding functions for potential customers, phone support, integration of Facebook and Twitter functions into applicable services are integrated in “FreshDesk” package. System tools are used for public and private reporting of incidents, receiving inquiries about incidents and organizing a solution. The following options are integrated, such as appliance monitoring panel, request volume trend reporting, request aggregation, general authentication and SSL certificate, DKIM (DomainKeys Identified Mail), and configuration features (FreshDesk.com).

In order to conduct an experimental study, certain disruptions in the organization's IT infrastructure were simulated and incidents resolved by means of the “FreshDesk”. Simulated disruptions such as incidents that may occur and are related to technical, software failures or human actions. Real incidents of technical failures in the educational organization are examined. There were several steps involved in experimenting with the “FreshDesk”:

- Registration on the FreshDesk.com website;
- Division of team members by roles: administrator, agents;
- Determination of incident type (urgent, medium, non-urgent) and execution time;
- Providing information about the performance of incidents;
- Reviewing and evaluating reports.

Internet connection and computer network functions for educational institutions are provided by LITNET computer network devoted for Lithuanian science and study institutions. The main LITNET services that can be provided to the organization are the following: Internet connection; wireless network Wi-Fi; Registration of domain names; email post office; website hosting; training.

Table 1. An example of structure of ICT infrastructure library of educational institution X

The structure ITIL of X Educational institution						
No	**Activities/functions**	**Hardware and Computer networks**			**Systematic standardized software**	**Applicational software**
		Types of Networks (WAN, LAN, WIFI, INT)	**Computer Work Stations**	**Other Technique**	**Operation systems. Cyber Security systems**	**Application Software Systems and Web Tools**
1.	Management of information and communication	WAN, LAN, INT (until 1 Gb/s, WIFI (~ 1 Mb/s, -~200 Mb/s). INT - fiber optic connection through LITNET	1. Ethernet 144 and more stationary working educational and teaching stations. 2. Wi-Fi – ~600 laptops and smart devices.	Software of Internet control: 1. Ethernet routers and switches, ~ 4 controlled and ~ 6 not controlled; 2. Wi-Fi access through MIKROTIK RB760iGS routers and switches UNIFI US24P250, 26 Wi-Fi points UNIFI U7LR.	Operation systems: 1. Stationary work station OS – MS Windows 10/11. 2. Smart devices with OS Android.; 3. Smart devices with iOS. Security systems: 1. In stationary work and educational stations – standard MS Windows OS safety toolkits 2. LITNET supported Ethernet and Wi-Fi Internet access data monitoring and filtering system using Fortigate with UTM software.	LITNET provides a monitoring and filtering system for Ethernet and Wi-Fi connection to the Internet Arrangement of Internet explorer systems and interoperable connection software for Data bases and data warehouses

The structure ITIL of X Educational institution						
No	**Activities/functions**	**Hardware and Computer networks**			**Systematic standardized software**	**Applicational software**
		Types of Networks (WAN, LAN, WIFI, INT)	**Computer Work Stations**	**Other Technique**	**Operation systems. Cyber Security systems**	**Application Software Systems and Web Tools**
1.1	Internet and cloud for communication and information sharing	WAN, LAN, INT (~ 1 Gb/s, WIFI (~ 1 Mb/s, ~200 Mb/s). INT fiber optic connection via LITNET	All PCs and smart devices		In „Google For Education“ platform applied safety and filtering systems	The Google For Education platform provides applications for stationary work and learning places and smart apps for phones, tablets and smart screens. Office 365 platform provided to schools by emokykla.lt. The official page of the organization - program PyroCMS, Inc 0.17 s | 14 mb v3.3.3
1.2	Management of web site of the institution		All jobs and Cloud service stations		Only employees authorized by the institution can connect to the content management systems (CMS) and domain management system of the website.	1. Web platform for managing of web site of educational institution; 2. the internet system: iv.lt -web client system for internet site management and domain control and internet service support plan realization. 3. The system wolet.lt - virtual server services for web site hosting
2.	Personal administration	LAN, INT	Work stations for Personal administration		User authentication and document signing system using e-personal certificate.	The portal is intended for managing and administering the income and expenses of the State Social Insurance Fund budget and interconnection with system: sodra.lt
2.1	Performing of administration functions	The separate LAN subnet for administration	PC for Administration	Printers, copiers, scanners, personal smart devices	MS Windows OS, Android OS, iOS. Only employees authorized by the institution can join; User authentication and document signing system using e-personal certificate.	1. Web platform: vatis.lt - Register of civil servants and civil service management information system (VATARAS/VATIS); 2. Portal of Administrative and public e-services :epaslaugos.lt

The structure ITIL of X Educational institution						
No	**Activities/functions**	**Hardware and Computer networks**			**Systematic standardized software**	**Applicational software**
		Types of Networks (WAN, LAN, WIFI, INT)	**Computer Work Stations**	**Other Technique**	**Operation systems. Cyber Security systems**	**Application Software Systems and Web Tools**
2.2	Administration of personnel and students	A separate LAN subnet for teachers/ students	Work stations for educational needs	Printers, copiers, scanners, personal smart devices, projectors and smart displays.	MS Windows OS, Android OS, iOS. Safe connection systems	1. Web system pedagogai.emokykla.lt – Register of staff. 2. Register of educational and scientific institutions: smir.smm.lt .
2.3	Staff planning and management	INT, inter DB	PC of document coordinator		MS Windows OS. Server Management system DBMS of Population register Sodra system	Software of personal administration and "Personalo apskaita"
2.4	Employee salary accounting	LAN, INT	Document coordination system, accountant's PC		MS Windows OS Software for connections with DMS and staff register	The system : Biudžetas VS
3.	Administration of students	A separate LAN subnet for teachers and students LAN ir WiFi.	A separate LAN subnet for teachers and students; Printers, copiers, scanners, personal smart devices, projectors and smart displays.		MS Windows OS, Android OS, iOS. Stricter filtering of student Wi-Fi data. e-mails; managing log-ins of users by providing passwords.	1. emokykla.lt – mokinių registras. 2. Švietimo ir ugdymo įstaigų valdymo Web sistema „My e-Diary"; 3. The system for distribution of study material - SharePoint
4.	Management of education process	LAN, INT				1. Program for creating lesson schedules „Mimosa" and/or aSc Timetables. 2. E-diary - „Mano dienynas. 3. Educational management information system: ŠVIS.
5.1	Management of internal and external	LAN, INT	PC for administration staff, remote servers		DW and access only to registered users using logins and passwords	Document management system; @vilys.

The structure ITIL of X Educational institution						
No	**Activities/functions**	**Hardware and Computer networks**			**Systematic standardized software**	**Applicational software**
		Types of Networks (WAN, LAN, WIFI, INT)	**Computer Work Stations**	**Other Technique**	**Operation systems. Cyber Security systems**	**Application Software Systems and Web Tools**
	documents					
5.2	Administration of archives	LAN, INT	PC for administration staff, remote servers		DB and access only to registered users using logins and passwords	E- archive system: eais-pub.archyvai.lt .
5.3	E-documents delivery		PC for administration staff, remote servers		DB and DW and access only to registered users using logins and passwords	National e-document distribution and delivery system – epristatymas.lt
6.	Finance management		PC for administration staff, remote servers		Data bases and access only to registered users using logins and passwords	Strategic planning information system bvs.klaipėda.lt
7.1	Security management: Access control, video sur-veillance system, atten-dance accounting systems	WAN, INT, Wi-Fi	Cards, biometric readers, video surveillance cameras, antennas, Server		MS OS; Student and employee card scanning system. TCP/IP, inter-relation RS232 RFID tags - cards, RFID scanner and software.	Software with RFID method (radio frequency identification). Automatic object identification method based on information storage and remote transmission using radio waves. Connections to "My Diary" then class attendance and staff working hours will be monitored.
7.2	Security and fire alarm systems		Control unit, transformer, battery, housing, sensors, magnetic contacts, siren, keyboard, expansion modules.		MS Windows OS The cameras and the equipment of perimeter of the building area and managed online software	Software for cameras and the perimeter of the building are managed online system; Information management system from the ex-commissar office.
8.	Accounting and operation of long-term tangible assets					
8.1	Building accounting	WAN, LAN, INT	PC of Administration, PC for inventory management		MS Windows OS. DB and DW and access only to registered users using logins and passwords	Register center self-service by registrucentras.lt/savitarna/
8.2	Planning and ma-na-gement of long-term and short-					Web platform bvs.klaipeda.lt - strategic planning IS and Register Inventory management system ICT service managing system FreshDesc

The structure ITIL of X Educational institution						
No	**Activities/functions**	**Hardware and Computer networks**			**Systematic standardized software**	**Applicational software**
		Types of Networks (WAN, LAN, WIFI, INT)	**Computer Work Stations**	**Other Technique**	**Operation systems. Cyber Security systems**	**Application Software Systems and Web Tools**
	term assets, training tools, ICT inventory					
8.3	Procurement organization	INT	PC of Administration		MS Windows OS. DW and access only to registered users using logins and passwords	1. Central public procurement system - pirkimai.eviesiejipirkimai.lt 2. E-centralized public procurement for suppliers and buyers - cpo.lt
84	Administration of library	INT	PCs of Library	Code reader	MS Windows OS. DW and access only to registered users using logins and passwords	1. MOBIS software for libraries – imobis.lt 2. Integrated information system of the libraries of the Republic of Lithuania LIBIS - Ibiblioteka.lt
9,	Health control system for personnel and students	INT	PC for Health specialist		MS Windows OS. DW and access only to registered users using logins and passwords	E-health system with health history and doctor recommendations - esveikata.lt

In order to conduct an experimental study, certain disruptions in the organization's IT infrastructure were simulated and incidents resolved by means of the “FreshDesk”. Simulated disruptions such as incidents that may occur and are related to technical, software failures or human actions. Real incidents of technical failures in the educational organization are examined. There were several steps involved in experimenting with the “FreshDesk”:

- Registration on the FreshDesk.com website;
- Division of team members by roles: administrator, agents;
- Determination of incident type (urgent, medium, non-urgent) and execution time;
- Providing information about the performance of incidents;
- Reviewing and evaluating reports.

Internet connection and computer network functions for educational institutions are provided by LITNET computer network devoted for Lithuanian science and study institutions. The main LITNET services that can be provided to the organization are the following: Internet connection; wireless network Wi-Fi; Registration of domain names; email post office; website hosting; training.

In order to be able to use the wireless network for the institution, it is necessary to use the online information system (IS) provided by LITNET (https://epaslaugos.lm.lt/). This IS can help for organization:

- To provide concrete services for administration of users by using the secure wireless access (Wi-Fi) to the Internet (teachers, students, employees, devices);
- To monitor the needful set of Wi-Fi zones (routers, switches, and access points).
- To organize filtering access to certain web pages.

LITNET online IS allows the searching process for users by first name, last name or Wi-Fi login name in the organization's user administration window. It is also possible to export user data in *.csv format and open it in MS Excel format. Such data sets are needed at the beginning of the school year, when login data is distributed to new teachers and students.

According to user types, it is possible to import *.xml format files into the IS, which are obtained by export from the Teacher and Student Registers. LITNET online IS provides an opportunity to offer one or another Internet resource to be added to the black or white list. Then such a resource can be blocked in the network or vice versa, a secure e-mail is created. LITNET's online IS allows solving the specific set of possible incidents due to visiting websites with unsafe or harmful content (Figure 3).

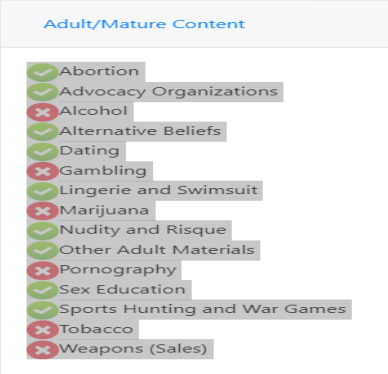

Figure 3. Possibilities of restricting the required website categories in LITNET online IS

For the content filtering, the filtering tool "Fortigate with UTM software" approved by the Communications Regulatory Authority of the Republic of Lithuania is used (Fortigate, 2021). IS allows for continuous monitoring of used Wi-Fi zones (routers, switches, and access points).

For illustration of the experimental research, the imitational activities are indicated in “FreshDesk” system for indication of administration incidents of ICT in institution (Figure 4). Incident scenario is described as follows: at October 31, 2023 the gymnasium received a phone call from LITNET that the IS recorded that the Wi-Fi access point in the school library stopped working properly, the downside is that this IS does not automatically inform the IT specialist of the gymnasium itself by “FreshDesk” system or other means of communication.

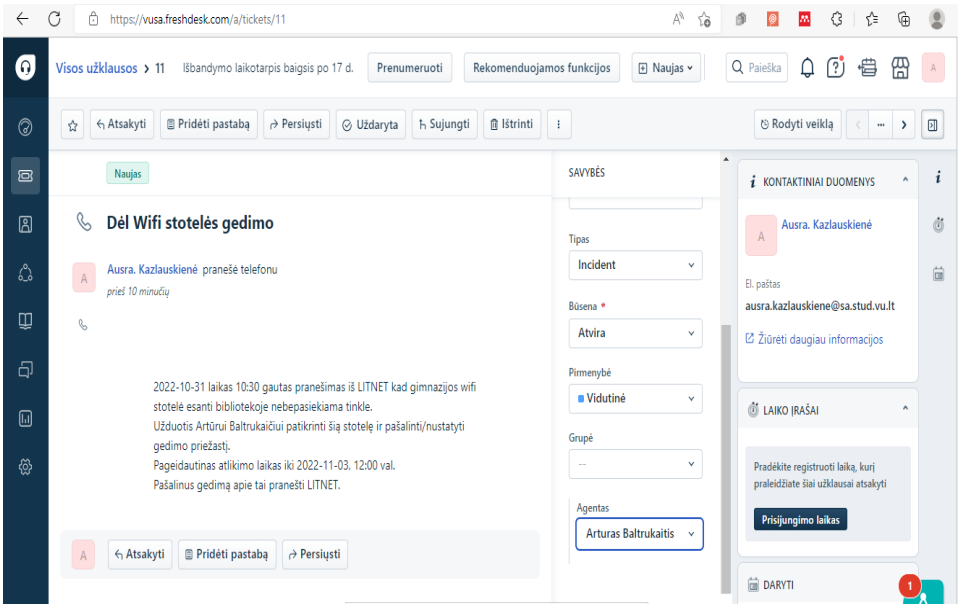

Figure 4. Illustration of managing of the incidents by logging into environment of the "FreshDesk" system

The incidents are categorized and applied for the "FreshDesk" support system. It was decided to link this incident to the mentioned platform and also to LITNET online IS, which is dedicated to Wi-Fi network monitoring. For that purpose, the ICT specialist was added to the required group in the "FreshDesk" support viewable by mobile phone platform (Fig. 5). A message registered in the "FreshDesk" support system can also be monitored in the smartphone mobile application. The moment of occurrence of the fault and the estimated deadline for its elimination are recorded in the system.

After receiving a new request, the ICT specialist has the ability to connect to LITNET IS and can determine - which access point is specifically disrupted, i.e., a Wi-Fi access point marked with M-304K index is found to be unreachable. The system can see the set of working switches and routers: their models, IP addresses, serial numbers, working and inactive ports.

Wi-Fi access points are visible in the system, i.e., data about: location, model, IP address, numbers of connected devices, data flow rate, availability, specific connected devices, their connection quality in percentage, MAC addresses, login names and data flow used. Since it was assumed that the Wi-Fi access point incident could be related to the Ethernet router in the office, another task was created in the "FreshDesk" system, which was assigned to the ICT specialist, and then both tasks were combined. This combination of work allows to reduce human resource costs. After the actions performed, the Wi-Fi equipment of X gymnasium started working properly.

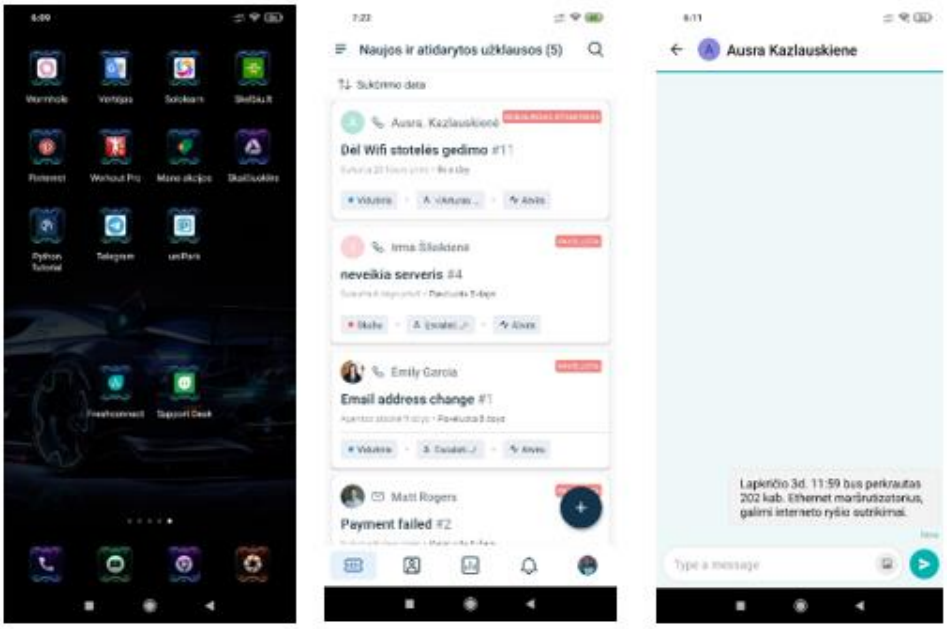

Figure 5. Illustration of activities how the "FreshDesk" request window is viewable and manageable on a mobile device

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Conclusions

Access to ICT management services and the ability to manage incidents and unanticipated ICT failures require appropriate knowledge, the right choice of ITIL methodology and dedicated software. One of the main advantages of the ITIL v4 methodology is that it is a methodology for ICT service management that integrates many features, which is important to use in order to achieve effective ICT service provision and increase the value of the organization's work. Effective provision and management of ICT services makes it

possible to ensure a better e-availability of services, a higher level of digitization of educational institutions, which also raises the achievements of the whole of Europe.

ICT infrastructure and its support services are becoming increasingly complex in educational institutions. Therefore, the training of suitable specialists and the mastering of methodologies will enable the proper performance of ICT infrastructure management services and the development of the use of computerized management systems for ICT infrastructure services in institutions of the education sector. Active cooperation with other state and international organizations with greater experience in this field should speed up the implementation of innovative service systems.

The ITIL service management methodology explains and creates a structure of service management processes, defining clear practices that allow effective management of services and elimination of service disruptions.

The efficiency of the management of LITNET and other online resources acquires no less importance. This especially requires appropriate service-responsive software so that the educational institution can manage the blocking system of Internet resources and enable blocking of unwanted websites and create a safe environment for access by students and employees. Software tools for ICT infrastructure management and service administration have a sufficient number of functionalities, which, when combined with network service software capabilities, optimize service capabilities. The article demonstrates how LITNET's online service IS could be supplemented with the "FreshDesk" system interface, and how online network management functions can be integrated into “FreshDesk” software tools. Proposals to supplement the available access to the LITNET online IS of the X gymnasium for the administration of the Wi-Fi network with an automatic message generation system, which would notify about the detected faults and enable them to be solved, are demonstrated in the article. The integrated application of such measures enables a more efficient, centralized management and resolution of incidents.

The results of the performed experimental works demonstrate how it is possible to combine the work of several very important ICT infrastructure management services from different systems and obtain appropriate functionality.

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