Ontology-based Representation of Digital Devices Used in Educational Guidance

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Abstract: School counseling is a decision-making process in which high school students have to decide what higher education course they will register for. Many digital devices support high school students in this guidance process. Given the diversity of architectures and services offered by existing devices, the main goal of this project is to predict their impact on high school students.
It is necessary, therefore, to propose a formal characterization of digital devices for school counseling. This paper proposes an ontology to represent knowledge of digital guidance devices. An instantiation of the ontology is performed for each device to be studied.
The ontology is built to be able to identify the different functions of the digital devices, their types, and the relationships between the tools of the digital devices and the guidance actors.
The ontology includes the tools that the user may use, the topics covered by the device, the elementary components, and the support used (mobile application, computer application, or website).

1 INTRODUCTION

In school counseling, various devices support the high school student guidance. We focus here on the study of the analysis of digital devices dedicated to guidance. The term digital device is a broad notion that includes tablets, mobile phones, and laptops (Viloria et al., 2020), (Lam and Tong, 2012) but also includes the interaction between the user and a digital tool (e.g. the possibility to change the display of content)(Treleani, 2014). As the difference between the terms platforms, devices, resources, and digital environment is not always clear (Durand et al., 2015), it is necessary to define a digital device in our context. Here we consider a digital platform as an "extensible codebase of a software-based system that provides core functionality shared by the modules that interoperate with it and the interfaces through which they interoperate", modules allow additional functionality to be added to the platform (Tiwana et al., 2010).

Using this definition, we consider immersive worlds, websites, and mobile applications. Not all have the same architecture, some devices offer an exchange tool, while others do not but have a job directory for example. In the context of guidance, digital devices do not all have the same objectives; some aim to inform, others to answer questions or to give ideas about careers. The motivation for this work lies in the fact that there is a diversity of architectures and services offered by existing devices. We propose to carry out a comparison and an evaluation of the latter. The final goal of this project in the future is to predict the impact of the digital devices on the users, i.e. on the students during their orientation process, for device developers.

It is necessary, therefore, to propose a formal characterization of digital devices for school counseling. With this aim, this paper proposes an ontology as a representation of digital guidance devices. Ontologies have appeared as suitable tools to represent the digital devices used in educational guidance. According to Gruber et al. (Gruber, 1993) an ontology is "an explicit specification of a conceptualization" and Noy et al. (Noy et al., 2001) "properties of each concept describing various features and attributes of the concept, and restrictions on slots".

In this paper an ontology-based representation to characterize the digital devices related to guidance is proposed. The remainder of the paper is structured

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as follows: Section 2 presents a review of ontology-based approach to characterize the digital devices or to characterize the guidance process. In section 3 we describe existing digital devices. Section 4 gives an overview of the proposed ontology. Finally, conclusions and perspectives are given in Section 5.

2 PREVIOUS WORK

Ontologies serve as a unifying framework for different points of view and capture the concepts used and the relationships between these concepts (Gandon, 2002) using a common vocabulary (Noy et al., 2001). Ontologies have several types of components:

- Classes: they represent the relevant concepts in the domain of interest and group objects sharing characteristics. They can contain instances and have subclasses.
- Relationships: these are used to link concepts together.
- Instances: these are named and concretely identifiable objects.

The construction of an ontology requires defining, identifying, and prioritizing these components in a specific domain of interest. Concerning educational ontologies, there exist several widely accepted and reusable ontologies across different applications.

Delestre et al. have proposed a description standard for education in France, part of which is represented as an ontology (Delestre et al., 2019). The ontology is a description of educational resources, these resources are notably linked to a ”target audience”, and have ”learning activities”. Bourdeau et al (Bourdeau et al., 2007) also propose an ontology in the field of education, their ontology is learner-centered. It allows for a description of the learner, such as their behavior, knowledge, and level. Learning is a domain in which several researchers wish to build ontologies since we also find the OMNIBUS ontology (Mizoguchi and Bourdeau, 2016). This ontology aims to help educational staff to apply knowledge from educational theories and to establish a method to build educational systems taking theories into account.

E-learning is a domain close to digital guidance devices since high school students using a digital guidance device are likely to be in a learning process. Guinebert et al (Guinebert et al., 2017) and Bennani et al (Bennani et al., 2020) deal with this domain using ontologies. The former (Guinebert et al., 2017) use their ontology to describe the scenario of the educational game, the roles that the players can take. This ontology describe the objective of the game and that of the teacher. Bennani et al (Bennani et al., 2020) have created an ontology on adaptive gamification in e-learning, which allows for example to represent the user, the interactions, and experiences he can have. The adaptation to the user of the digital device is also treated by Bacha et al (Bacha et al., 2010) but this time without the notion of a game, their ontology allows them to describe the user (his profile, his preferences, ...), the platform and the environment in which the user uses the platform (location, date, ...).

The ontologies presented above allow for the description of the learner or user of the device in context but take less account of the tools available to the user or the type of interface with which the user interacts.

3 EXISTING DIGITAL DEVICES

Existing digital devices have varying objectives, themes, or media. It is interesting to present some of them to illustrate this diversity and therefore the difficulty that there may be in uniformly representing them.

Some schemes are intended to be available one day a year, operating similarly to face-to-face guidance days. For example, the digital device Virbela was used for the CapSup 4.0 day (part of the Printemps de l’orientation) on 16 March 2021 (Gribouval et al., 2021). The CapSup day is an event that regroups higher education courses. It aims to introduce high school students to the various courses available in higher education and provide guidance counseling. Virbela platform (https://www.virbela.com) is an immersive 3D world, each user is represented by a character. The user can move his character in the virtual world.

Other devices have elements available that vary throughout the year, such as Parcoursup (https://www.parcoursup.fr). To access it, you have to be a high school student, and depending on the trimester of the year and therefore the orientation stage, the content varies to follow the high school student from his or her reflection to the validation of his or her higher education choices. For example, between 20 January and 20 March, high school students in their final year had to register on the platform and add their post-bac training wishes.

A larger number of devices are accessible all the time so that students can go to them at any time of the year when they feel the need. Within this set of continuously accessible facilities, not all offer the same services. Some have focused on providing a wide range of information and offer numerous pages on careers, student life, and the various diplomas, as is

the case with the Onisep site (https://www.onisep.fr). Another existing possibility is that of systems focusing on one type of information. This is the case of the Wilbi mobile application (https://wilbi-app.com), which deals only with careers, and is designed to resemble the mobile applications that high school students are usually used to using. It is professionals themselves who film small parts of their day to present their job. Some devices offer little information content but aim to help high school students get to know themselves better through tests. This is the case, for example, with the Hello Charly application (https://hello-charly.com/), which is a robot that asks multiple questions during a conversation and then proposes ideas for jobs that match the student's profile.

The ontology proposed in the following section allows these devices to be represented through instantiations of the ontology.

4 ONTOLOGY-BASED PROPOSAL REPRESENTATION

Various methodologies exist for developing an ontology, several of which are presented in (Cristani and Cuel, 2005). We have chosen to use an evolving prototype model because this type of model is adapted to a dynamic or difficult-to-understand environment. The second type of model is the stepwise model for problems where the objective and requirements are clear. The model chosen is "Ontology Development 101" (Noy et al., 2001) as it is cited in a various research documents and presents a detailed definition to each step.

4.1 Ontology Development

The first step in building the ontology is to determine the domain and scope. Our ontology should allow us to characterize digital devices related to school guidance and to understand how we relate to digital devices and school guidance. The ontology is constructed in such a way that it can answer the following questions:

- What are the different functions of digital devices for guidance?
- What are the different types of digital devices for guidance?
- What are the relationships between the tools of digital devices and guidance stakeholders?

The second step in this construction is to list existing ontologies that can be used for our problem. We started by doing a broad search of existing ontologies in the field, including those dealing with the guidance. As these ontologies do not consider digital devices, we looked for ontologies dealing with digital devices in the field of the training process. The ontologies presented in the section 2 do not include a description of digital devices.

The "Web content accessibility guidelines" (Caldwell et al., 2008), although not a taxonomy or ontology, lists the important elements present in a digital device. It is a guide to making web content more accessible to people with disabilities such as blindness or deafness.

These references help to create a list of important terms of the ontology and to create a hierarchy between them. This is the 3rd and 4th step in the construction of the ontology. To create a fairly exhaustive list of terms, the functionalities of several guidance systems are observed (Table 1). We have chosen these devices because they are among the most frequently used devices and represent a variety of devices (they do not all have the same objectives, the same supports). In the functionalities, we can find tests suggesting jobs according to one's favorite fields, and communication tools allowing to ask questions to students.The observation of existing devices when creating the ontology avoids problems of inconsistency, allows for self-explanatory and easy-understandable models (Peroni, 2016).

Table 1: Table of digital guidance devices observed.

Name of the digital device	Device link
Onisep	https://www.onisep.fr
Pixis	https://pixis.co
Quel métier	https://www.quelmetier.fr
Bloom'r	https://www.bloomr.org
Génération15-25	https://www.generation1525.fr
Recto Versoi	https://www.recto-versoi.com
Jobirl	https://www.jobirl.com
Study Advisor	https://www.studyadvisor.fr
Wilbi	https://wilbi-app.com

We chose to create the ontology using Protégé (https://protege.stanford.edu).

4.2 General Overview of the Ontology

The instantiations of the ontology should highlight the differences between the digital devices.

The main class "DigitalDevice" is instantiated for all the digital devices studied. The instance name corresponds to the device name. We consider digital devices as having some tools, at least one subject, one

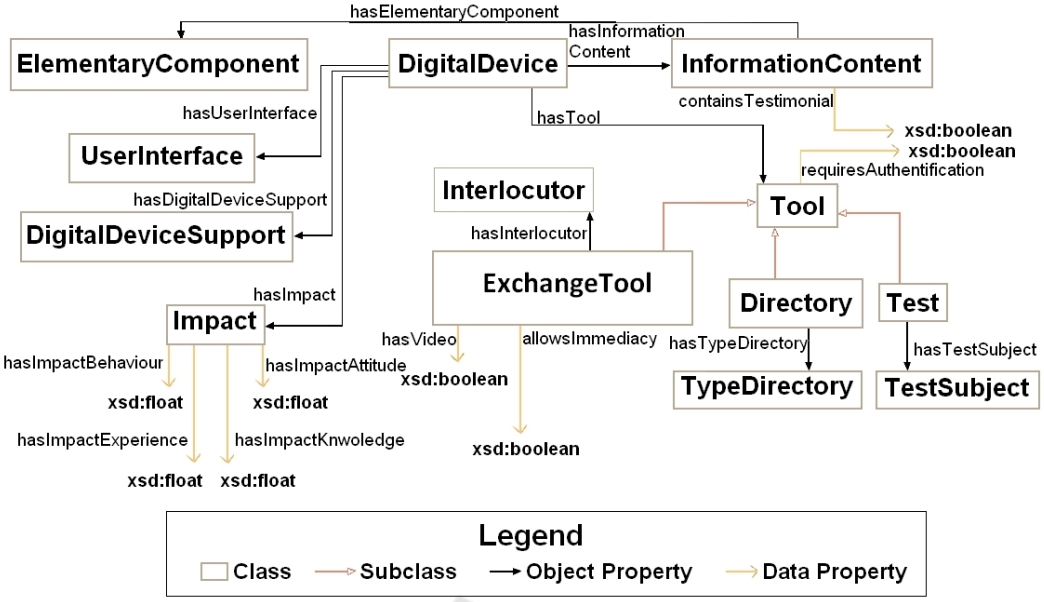

Figure 1: Extract from the representation of the proposed ontology.

user interface, exactly four impacts (behavior, knowledge, experience, attitude), and one support (e.g. a mobile application).

Others ontology classes should consist of their main characteristics.
An important point of distinction is the content(s) addressed by the device. Thus, the content class identifies the topics that each digital device deals with. Its sub-classes are the possible subjects treated, for example, information on jobs, on student life, ...

The tool class is also one of the main classes as it contains the tools that can be present in digital devices. The tools can be exchange tools, directories, or tests.

It is the ”hasInformationContent” (respectively ”hasTool”) relationships that link the ”DigitalDevice” class with the ”InformationContent” (respectively ”Tool”) class.

An overview of the classes and properties from the proposed ontology is shown in Figure 1. This figure is an excerpt of a larger ontology that can be found in our code (https://github.com/MarieGribouval/OntologyDigitalDeviceForGuidance).

During the first instantiation of the ontology for a given device, we realised that the process of creating an instance for each page and each page subject was too time consuming. Indeed, for the Onisep site, 792 instances would have had to be created to represent each job description in addition to all the other domains covered by the site. This first instantiation led to a fairly significant modification of the ontology. Boolean data properties were added in order to simplify the instantiation process of each device (for example, the instances of the Tool class require or do not require authentication).

Moreover, the stages of the orientation process that we initially thought to include were not included in the end because when using the ontology in a concrete case the context of use of each student is very variable, the device can generally be used by a student at any time.

The complete set of concepts and their definitions is presented in Table 2, including the hierarchy between the classes. To describe and link these concepts, some relations are proposed. The ontology consists of 23 concepts, 9 object properties and 9 data properties.

The object properties are shown in Table 3, the object properties not shown are the inverse object properties, for example, the inverse property of ”hasElementaryComponent” is ”ifElementaryComponentOf”.

Table 3 presents the data properties. These four data properties are of boolean type, i.e. they have the value ”true” or ”false”.

When instantiating the ontology for each digital device, we also use the inference engines available in Protégé. The inferences allow us to check that the instantiation constructed is consistent (e.g. that a class is not put with a data property that does not match) and also to facilitate development by inferring implicit knowledge.

Table 2: Table of ontology concepts and their associated definitions.

Concept	Definition
Digital Device	Digital object with user interface(s), information, support and possibly tools
Digital Device Support	The digital device can be a mobile application, a computer application or a website
Elementary Component	Represents all audio, external, and internal hyperlinks, images, texts, and videos
Impact	A very strong impression or effect left on someone as a result of an action or event
Information Content	The subject of all or part of the digital device
About the Device Information	Description of the purpose of the device, and its members
Employment Internship Information	Job offers or internships, or advice on them (e.g. writing a cover letter)
Guidance Information	Information on path chosen as part of their studies
High School Information	Information about secondary school (from the second to the final year).
Job Information	Information about regular and paid professional activity
Post Secondary Education Information	Information related to higher education
Training Institution Information	Information on post-baccalaureate institutions
Training Diploma Information	Information related to post-baccalaureate training or act conferring and attesting a title, a rank
Psychology Personality Information	Information related to one's personal internal functioning (e.g. how to know what one's aspirations are).
Student Life Information	Information about student life (e.g. about student accommodation)
Interlocutor	Entity or individual with whom the user can exchange (i.e. transmitting something and receiving something - where the thing transmitted can be audio, video, text, images -)
Test Subject	The result of the test can give information on the user's interests, jobs that correspond to them, or their personality
Type Directory	The directory can be used to list schools, students, training courses, high school students, professions, guidance professionals, or professionals for a particular profession
Tool	A set of tools that the user can have at his disposal in a digital device
Directory	Tool storing information (people, institution, job, training). The information can be obtained through filters and a search bar
Exchange Tool	A tool for exchanging (i.e. transmitting something and receiving something - where the thing transmitted can be audio, video, text, images -)
Test	A form that the user can complete and which returns a result
User Interface	Allows you to describe whether it is a "classic" interface per page or an immersive world

4.3 Ontology Evaluation

We evaluate the ontology according OOPS! (https://oops.linkeddata.es/). The OOPS! tool can also identify errors in an ontology. It detects structural errors (the syntax and formal semantics), functional errors (considers the intended use and functionality of the proposed ontology), and usability

Table 3: Table of object and data properties used.

Object properties	**Definition**
hasDigitalDeviceSupport	Relation denoting that an entity has a digital device support
hasElementaryComponent	Relation denoting that an entity has an elementary component
hasImpact	Relation denoting that an entity has an impact
hasInformationContent	Relation denoting that an entity has content
hasInterlocutor	Relation denoting that an entity allows communication with an interlocutor
hasTestSubject	Relation denoting that an entity has a test subject
hasTool	Relation denoting that an entity has a tool.
hasTypeDirectory	Relation denoting that an entity has a type directory
hasUserInterface	Relation denoting that an entity has a user interface
Data properties	**Definition**
allowsImmediacy	Relation denoting that an entity for immediacy or not
containsFaq	Relation denoting that an entity has a set of frequently asked questions
containsTestimonial	Relation denoting that an entity owns a testimonial or not
hasImpactAttitude	Relation denoting that an entity has an impact on attitude and gives the value of that impact
hasImpactBehaviour	Relation denoting that an entity has an impact on behaviour and gives the value of that impact
hasImpactExperience	Relation denoting that an entity has an impact on experience and gives the value of that impact
hasImpactKnwoledge	Relation denoting that an entity has an impact on knwoledge and gives the value of that impact
hasVideo	Relation denoting that an entity owns a video or not
requiresAuthentication	Relation denoting that an entity requires an authentification or not

profiling errors (communication context of an ontology) (Poveda-Villalón et al., 2014). Using OOPS! on our ontology gives the result in Figure 2. The 43 minor errors are due to the lack of annotation for classes and data properties. The major error is caused by the lack of a license specification, this does not impact the current operation of the ontology. We will have to fix it when we make the ontology available.

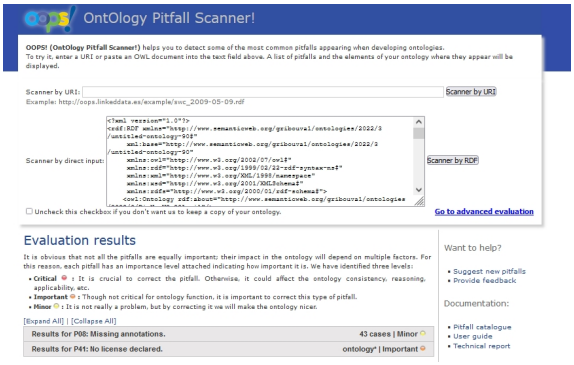

Figure 2: Screenshot of the results of the OOPS evaluation of our proposed ontology.

5 CONCLUSION AND FUTURE WORK

The ontology proposed here allows us to characterize digital devices related to school guidance by describing them according to their tools, content, the support used, and elementary components. To do that, an instantiation of the ontology is performed for each device to be studied. Instantiation from an initial ontology allows each device to be represented uniformly and thus makes a formal comparison between devices possible. The use of an ontology to represent digital devices allows reasoning during instantiation and thus verifying the consistency of the instantiation as it is a manually performed task. Moreover, ontologies allow the possibility of adding other concepts or relations if in time other very different devices emerge.

In the future, we would like to obtain the impact of digital devices on high school students. This measure is the key point of this research. We will need a prediction algorithm to determine the impact. Indeed, calculating the impact of a device will require the intervention of an expert or the use of an evaluation method because calculating an impact is a com-

plex process that will require multiple knowledge.

The instantiations of the ontology will provide one part of the uniform description of the devices. The second part of this description will consider the usability of devices. Usability is the effectiveness, efficiency, and satisfaction with which the user achieves his or her goals using the digital device (Mustafa and Al-Zoua'bi, 2008). Usability data will collect using a questionnaire.

Thanks to this ontology-based characterization and usability data, which will provide a uniform description of the devices, will allow us to calculate the similarity between different digital devices. The similarity calculation will be used when predicting the impact. The similarity measure will be used in a case-based reasoning algorithm by calculating the similarity between the device whose impact is to be predicted and devices whose impact is known. Each device will be represented by a uniform description which is an instantiation of the ontology and usability dataset and by an impact value. The case-based reasoning will allow for expanding a knowledge base (i.e. the set of pairs (ontology instantiation and usability data, impact)). This knowledge base enrichment will be of interest in our problem because we will have a small amount of impact data initially and it will increase the quality of impact prediction for new digital devices.

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