Mapping between Pedagogical Design Strategies and Serious Game Narratives

Frederik Van Broeckhoven*, Joachim Vlieghe†, Olga De Troyer‡
Department of Computer Science - WISE*†‡
Vrije Universiteit Brussel
Pleinlaan 2
B - 1050 Brussels, Belgium
Email: Frederik.Van.Broeckhoven@vub.ac.be*, Joachim.Vlieghe@vub.ac.be†, Olga.DeTroyer@vub.ac.be‡

***Abstract*—Successful serious games include a compelling narrative context and empirically validated pedagogical intervention methods. In order to create such games, design teams must consist of a multidisciplinary group of technical and pedagogical experts. In this paper, the authors show how the domain specific modeling language ATTAC-L facilitates communication between designers with different expertise, thus enabling and stimulating multidisciplinary collaboration. As a serious game design tool, ATTAC-L creates a link between the processes of pedagogical design and narrative modeling through its elaborate annotation system. As such, this modeling language enables designers to concentrate on aspects related to their field of expertise without losing oversight of the serious game as a whole. To support these tentative claims, the author present illustrations of how ATTAC-L is used in combination with a specific pedagogical design strategy (i.e. the Intervention Mapping Protocol) for the development of a serious game against cyber bullying.**

I. Introduction

Serious games that provide a narrative context are generally more effective at conveying knowledge and achieving behavior change. This claim is supported the empirical findings of several studies on effective game design (see see [1] for an overview). Therefore, serious game designers choose to present pedagogical content and interventions through an interactive natrrative. To ensure effective learning in such a serious game, the developers are not only faced with the challenge of creating a compelling narrative, but also with the additional challenge of incorporating suitable learning strategies into their narratives. Thusfar, designers are faced with a lack of general guidelines or standards for making such combinations.

To come to well-grounded and effective serious games, different parties should be involved in the development of serious games: game developers as well as pedagogical experts and subject-matter experts. Subject-matter experts bring in their knowledge about the subject of the serious games (e.g., cyber-bullying), pedagogical experts share their knowledge on how to ensure the learning that is aimed for (e.g., knowledge acquisition, attitude change, and/or behavior change), while game developers contribute their experience on how to develop a challenging game. However, pedagogical experts are usually no game or software engineers, and game developers are usually not trained in pedagogical design. This often results in a communication gap that can seriously hinder the proper development of these games [2]. In addition, there is little common knowledge on how to incorporate pedagogical principles and techniques into game narratives. Although some research has attempted to map pedagogical principles onto game mechanics (see e.g., [3]), clear guidelines for designing games in an interdisciplinary setting are lacking.

In previous publications [4], [5], we have argued for the use of a Domain Specific Modeling Language (DSML) to support people with limited technical backgrounds in participating in the specification of serious games narratives. This kind of a modeling language is often visual in nature and its syntax contains the vocabulary of the domain under consideration [6]. We proposed such a DSML - called ATTAC-L - for specifying the storyline, as well as the pedagogical aspects of educational video games. It combines flow chart principles and a natural language based syntax that facilitates participation by non-technical experts in the narrative modeling of a serious game. The output generated by the DSML results in a formal specification that can be processed automatically to generate code.

In previous publications, we focused on the visual representation of the DSML and its natural language-based syntax [4]. In [5], we proposed a mechanism, i.e. pedagogical annotations, to model pedagogical aspects in the narrative of a serious game. These annotations are specified on top of the storyline and allow the modeler to associate pedagogical issues, such as objectives and actions, with particular parts of the story. In these publications, however, we did not yet consider methods or guidelines for identifying these pedagogical aspects or incorporating existing learning strategies. In this paper, we tackle this issue by showing how a well-documented pedagogical design strategy, i.e. the Intervention Mapping Protocol (IMP) [7], provides such guidelines and how its outcomes can be linked explicitly with the narrative of the serious game using the annotations of ATTAC-L.

The paper is structured as follows: Section II discusses related work, section III explains IMP and section IV briefly describes ATTAC-L. Section V discusses how the modeling concepts of ATTAC-L and the annotations in particular can be used to link the narrative to the outcome of an IMP process. Section VI presents conclusions and future work.

II. Related Work

IMP has already been successfully applied for the development of serious games and digital intervention platforms. 'PR:EPARe' [8] (Positive Relationships: Eliminating Coercion and Pressure in Adolescent Relationships) is a game developed as part of an intervention program for teaching relationships and sex education for young adolescents in the UK. 'The Gay Cruise' [9] and 'QueerMasters' [10] are both intervention programs addressing HIV-prevention in the Dutch homosexual community. Although the latter two are not explicitly presented as serious games, they are similar in the sense that these cases use virtual narratives in which the characters introduce the participants to the issues at hand.

The main advantages of IMP are the involvement of a wide range of collaborators (technical as well as non-technical) in the development process and the sound foundation the protocol provides for validating the effect of the intervention. The project presented above where successful at reconciling a pedagogical design strategy - in this case IMP - with the process of game development without the use of a dedicate design tool. In other cases, this proved to be a very challenging undertaking due to a large communication gap between the experts involved[11]. While there is a growing need for specialized game authoring tools that take into account pedagogical design principles, current research on this topic is very sparse. Furthermore, to our knowledge, tools specifically based on the effective design strategy of IMP are non-existent at this moment.

Different authoring tools can be used for designing scenario-based serious games, such as interactive digital storytelling tools, e.g., StoryTech[12], Scenejo[13], e-Adventure[14]. Also, several DSMLs were developed for the same purpose, e.g., WEEV[15] and GLiSMo[16]. Most of these systems concentrate on one aspect, mostly the game story. Here, we will not discuss them, we will review work that also aimed for linking pedagogical design principles to the narrative.

EDoS (Environment for the Design of Serious Games) [17] is an interactive authoring environment for serious games. Its purpose is similar to that of ATTAC-L: to help an interdisciplinary team in designing a serious game through a number of standardized steps, from formalizing the pedagogical objectives, to elaborating a scenario and modeling user interactions. The outcome is also "a structured scenario that will be automatically executed by an engine" [17, p. 1]. EDoS focuses on the reuse of available components of different granularit and the creation of serious games for teaching engineering skills. The design process builds on 3 models. The first one is a model of the targeted pedagogical objectives, e.g. professional competences for an engineer. The second model relates pedagogical objectives to pedagogical activities in order to form a pedagogical serious game scenario. These scenarios are created using an adapted version of the IMS-LD (Instructional Management Systems - Learning Design [18] language, and only describe the pedagogical content of the serious game. The third model helps to include the entertaining elements, i.e. the task model that describes the screens with which the users will interact. In contrast with the approach of ATTAC-L, the EDoS approach relies on a specific learning design, i.e. IMS-LD, thus providing limited flexibility. Furthermore, publications related to EDoS do not provide guidelines or methods for identifying pedagogical objectives or constructing serious game scenarios.

TABLE I: Example of matrix for performance objective 'Always comfort the victim', determinants and change objectives

Performance Objective: ***PO*** - Always comfort the victim	
Knowledge	*K1* - Recognize that by comforting the victim, you are making the victim feel better *K2* - Describe ways to comfort a victim that are in line with your personality
Self-efficacy	*Se1* - Express confidence in being able to comfort or provide advice to the victim
Outcome expectancies	*Oe1* - Expect that by comforting the victim, he/she will feel better
Perceived social norms	*Sn1* - Recognize that your friends expect you to comfort or provide advice to the victim

III. Intervention Mapping Protocol

The Intervention Mapping Protocol (IMP) has been developed to aid in the systematic planning and design of behavioral change programs. The protocol stimulates an ecological approach to the design of behavioral change programs focused on health issues [19]. It recognizes the importance and bi-directional influence of individual and environmental factors of behavior (e.g., peers, family relations, school policy). The aim of the IMP is to increase the efficacy of the design process as well as the intervention program itself. It does this by means of a set of six clearly defined steps which include iterative cycles of reviewing evidence of problem-related determinants, selecting and implementing theory based strategies, and consulting stakeholder [7]. IMP encourages its users to document the design process and to create detailed descriptions of the foundations and different steps of the intervention. As such, the protocol also meets the recent and popular demands for more thorough reporting.

In what follows, we first provide a detailed description of IMP and then briefly explain how IMP can be used for the development of serious games.

A. IMP Outline

IMP consists of the following steps: needs assessment, preparing matrices of change objectives, selection of theory-informed intervention methods and practical strategies, development of the intervention program, planning for adoption, implementation and sustainability, and development of an evaluation design.

Step 1: Needs Assessment

The first step in IMP is to define the program goal or health problem(s) that the intervention will tackle. This includes identifying the population at risk and developing an understanding of their environmental context. The program goal is refined into program objectives. Each of these objectives is defined in terms of a desired outcome and has a

priority. The priorities are set based on the objectives level of relevance, desirability, changeability, as well as the required means and efforts to achieve it [7].

Step 2: Preparing Matrices of Change Objectives

This second step compromises an investigation of the behaviors that can help to reduce the problem and attain the program objectives. In the literature related to the IMP, the term performance objectives is used to refer to the set of desired behaviors. For each of these performance objectives the program designers must assess which factors influence the performance of the desired behavior. Based on this assessment, behavioral determinants are identified. What needs to be changed in relation to these determinants in order to achieve the performance objectives is then formulated in terms of change objectives. These change objectives create the basis for the development of the actual intervention steps. For each performance objective, the determinants and change objectives are formulated in a matrix of change objectives. Table I shows and example fragment of such a matrix for a program to decrease cyber-bullying. The performance objective considered is '*always comfort the victim*'. Behavioral determinants are 'knowledge', 'self-efficay', 'outcome expectation', and 'social norms'. For each of these determinants, the change objectives are given. So for example, for the determinant '*knowledge*' the following change objectives are targeted: '*K1: Recognize that by comforting the victim, you are making the victim feel better*' and '*K2: Describe ways to comfort a victim that is in line with your personality*'.

Step 3: Selection of Theory-informed Intervention Methods and Practical Strategies

During the third step, different methods are selected from a body of available literature and assessed in light of the change objectives. This means that for each of the change objectives, the program devolopers try to find a method that has been tested and said to impact the type of behavioral change that they intend to achieve [7]. These are then matched with other methods to form practical strategies.

Step 4: Development of the Intervention Program

In this fourth step, all information of previous steps is combined to develop an Intervention Plan. Information from step 4 is also used to revise decisions made in step 3.

Step 5: Planning for Adoption, Implementation and Sustainability

Although listed as step 5, implementation planning runs throughout the whole development process. To ensure that the finished product would be feasible to use in practice, a group of stakeholders (e.g., teachers, schools, school counselors, youth advisory centers) is set up at the onset of the project to provide feedback.

Step 6: Development of an Evaluation Design

Similarly, step 6 runs throughout the whole development process. This step covers the evaluation of the intervention program, which is performed by conducting formative research and assessing effectiveness together with end users.

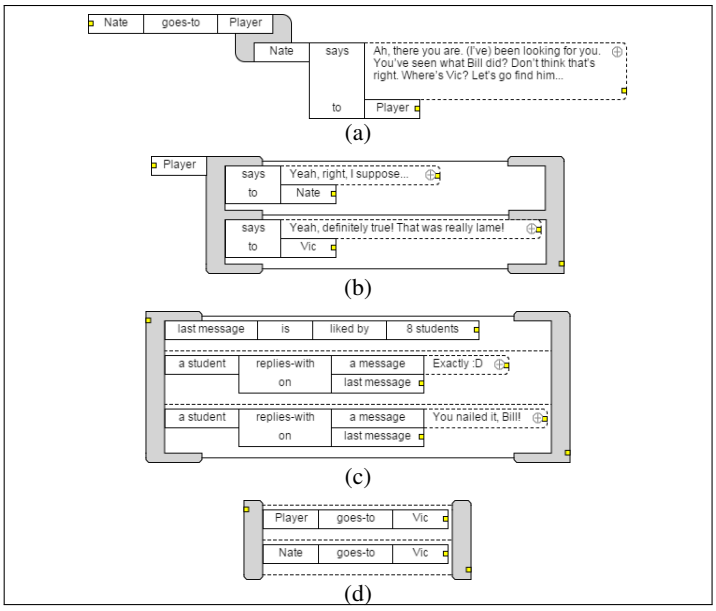

Fig. 1: Several ATTAC-L control structures (fragments taken from figure 5).

B. IMP for the Development of Serious Games

IMP allows for the systematic planning and design of behavioral change programs. A serious games could be part of such a program as a way to accomplish the performances objectives, though it may still be useful to complement it with other components, such as media campaigns, lectures, lessons, etc... The serious game should then be designed (as part of step 4) to target the associated change objectives using identified intervention methods and practical strategies (in step 3). The implementation of the serious game is part of step 5 , while its evaluation is part of step 6. Note that step 6 actually runs throughout the whole development process, which is in line with good software engineering practices. IMP is also in line with a user-centered software development approach [20] given the incorporation of stakeholders.

IV. ATTAC-L

ATTAC-L is a Domain Specific Modeling Language for specifying the storyline of educational video games. It combines a syntax based on natural language with flow chart modeling principles to allow both technical and non-technical people to model (i.e., describe in a formal way) the narrative of an educational video game. The output, a formal specification of a game narrative, can be processed automatically to generate code.

A first basic modeling concept in ATTAC-L is a *game move*, i.e. a single action in the narrative [21]. It represents one individual step in the game narrative, either performed by the player or 'automatically' by a non-playable character (NPC). To form a story, game moves should be linked to each other to denote their relative order in the narrative. For

this, ATTAC-L adopts principles from flow-chart modeling (e.g., UML[1]). The modeler can express sequence (i.e., game moves following each other), choice (i.e., branching, defining alternative story flow paths), and concurrency (i.e., story flow paths that are performed in parallel). In addition, ATTAC-L provides an extra control mechanism to increase its expressiveness, i.e. 'order independence'. This mechanism allows designers to determine that particular story flow paths must all be performed regarless in what order.

A second important modeling concept is a *brick* (adopted from the StoryBricks[2] framework). Bricks are the basic building blocks used in ATTAC-L to compose the game moves as well as the overall flow. Two classes of bricks are distinguished: *regular bricks* and *control-bricks*.

Regular bricks are used to construct game moves. They correspond to the smallest meaningful unit that exists in the context of a story. This can be an act to be performed, a tangible object that can perform or undergo the act, a state, or a value. Game moves are constructed by interconnecting bricks according to rules that are based on a controlled natural language [22]. The result is a construct that reads as a simple sentence and denotes a game play activity. A regular brick is graphically represented by a rectangle containing a word or word-group that gives it a meaning. In figure 1, the white rectangles containing words are regular bricks. As can be seen, the bricks are combined to form simple sentences, i.e., the game moves. For example, the game moves in figure 1a are "`Nate | goes-to | player`" and "`Nate | says | 'Ah, there you are ...' | to | player`". We refer to [22] for details about constructing game moves.

Control bricks are used to express temporal relationships between game moves. As stated earlier, ATTAC-L uses a flow-based structure for this because empirical evidence shows that this is more suitable for non-technical users [4]. Because the target users are not familiar with the typical flow-chart notation used in modeling languages such a UML, we have decided to use bricks as well te express these control structures. In figure 1, the grey bricks that interconnect game moves are control bricks. We distinguish bricks to model sequence, choice, order independence and concurrence. A sequence-brick is visualized by a chair-like brick that interconnects game moves. In Figure 1a it is used to specify the order between the two game moves, so that Nate first goes to player after which he says 'Ah, there you are. I've been looking…' to player. A choice-brick encapsulates alternative storyline paths. Figure 1b shows a choice for the player between saying 'Yeah, right I suppose' or 'Yeah, definitely true! That was really lame!'. Similarly, an order independence-brick encapsulates storyline paths that must all be performed, but in any order. Figure 1c expresses that 8 students like the message and two reply with 'Exactly :D' or 'You nailed it, Bill', but the order in which they do it is irrelevant. Finally, a concurrence-brick encapsulates storyline paths that are performed in parallel. Figure 1d specifies that both player and Nate go to Vic at the same time.

[1]Unified Modeling Language

[2]http://www.storybricks.org (project discontinued since 03-05-2015)

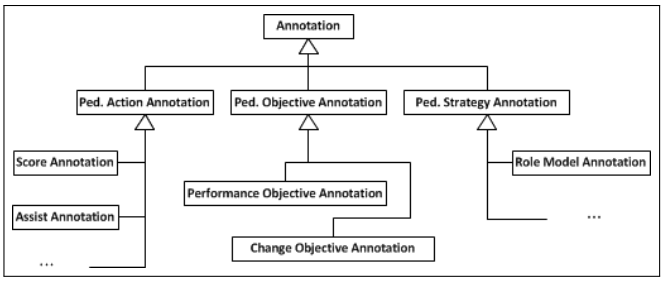

Fig. 2: Annotation class-hierarchy

A third modeling concept is called a scenario. This concepts was introduced to deal with the complexity of large models. It allows designers to divide a large narrative into smaller logical units. The so called scenario-bricks refer to different scenarios by name. They function as placeholders for scenarios and can be arranged like game moves in a story line. Figure 5 shows a storyline decomposed into scenarios. The overall scenario 'Introduction to Comforting', contains two scenarios 'Vic's bullying situation' and 'Nate demonstrates comforting'. The corresponding scenario-bricks (shown at the top of the example) are linked to each other using a sequence-brick. This means that first the scenario 'Vic's bullying situation' is performed, next the scenario 'Nate demonstrates comforting'.

The fourth modeling concept in ATTAC-L enables the modeler to specify additional information (e.g. pedagogical relevant information) to parts of the storyline model, i.e. annotations [5]. Annotations are represented graphically by means of small and square-like bricks, called annotation-bricks. Each brick contains an icon that denotes its meaning. They can be attached to game moves and scenarios. Annotations allow the modeler to specify and add relevant non-storyline related aspects on top of the storyline model, such as pedagogical aspects (e.g. pedagogical interventions) . This prevents that the specification of different aspects (here learning and gaming) are entangled. It allows for a clear separation between the narrative content and the educational aspects while the modeler can still relate the latter to the story flow.

Currently, ATTAC-L distinguishes between pedagogical action annotations, pedagogical objective annotations, and pedagogical strategy annotations. Pedagogical action annotations are used to specify particular pedagogical oriented actions that should be performed in the story, such as providing additional information, assistance or feedback (i.e. pedagogical interventions). Pedagogical objective annotations are used to explicitly relate behavioral change objectives to scenarios. An example of such an objective could be "to practice the multiplication tables of 1 to 10", but also "to realize the impact of cyber-bullying". Pedagogical strategy annotations are used to associate pedagogical strategies to the story or scenarios. Examples of such strategies are 'drill & practice', 'trial and error', or 'learning by doing'.

V. Linking Narrative and IMP Outcome

As explained in section III, a serious game could be used to achieve the performances objectives identified by through IMP. When a serious game is part of a program developed

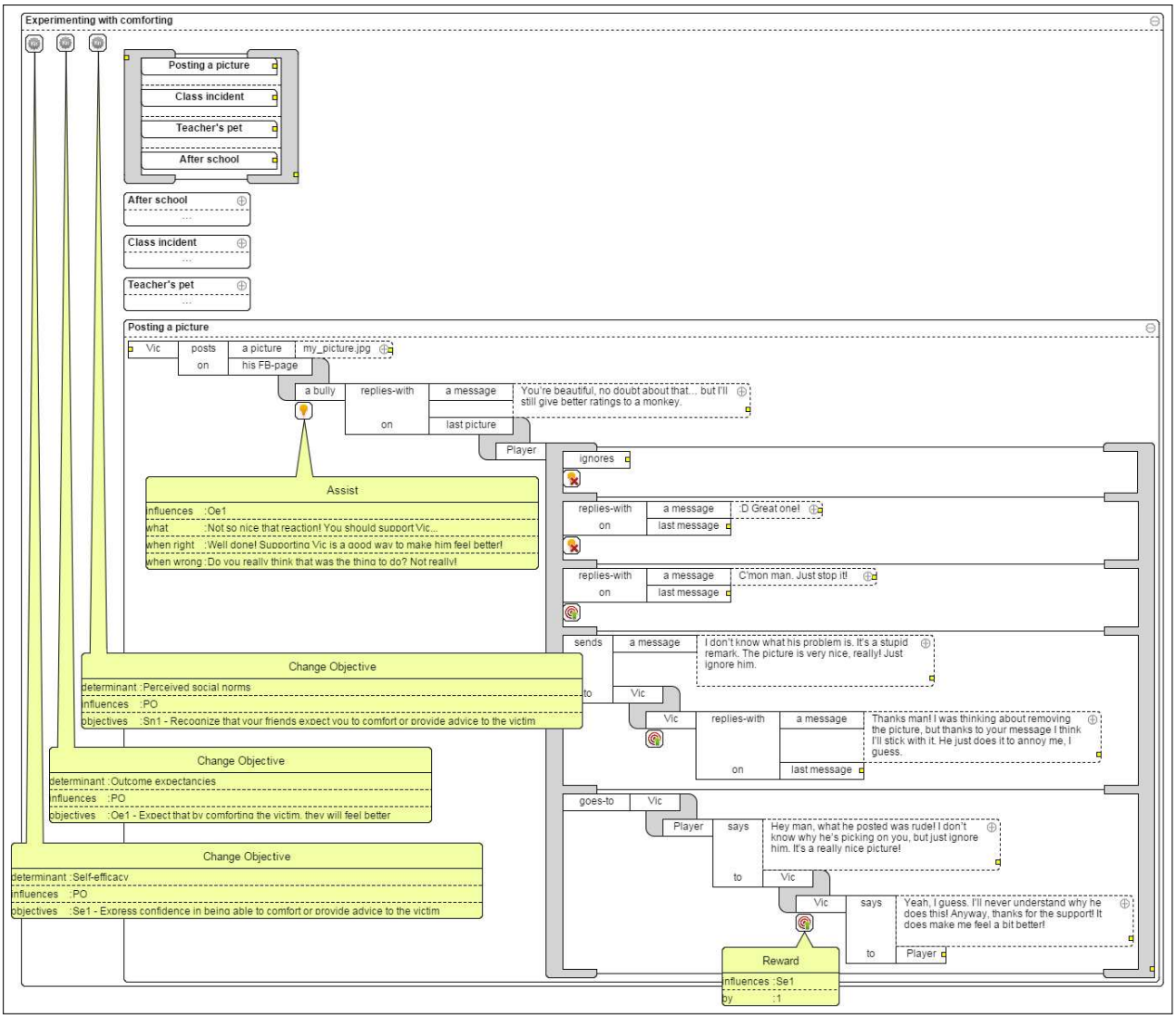

Fig. 4: A scenario with change objetive annotations for determinants 'self-efficacy', 'outcome expectations' and 'perceived social norms' and ped. action annotations for 'scoring' and 'assistance'.

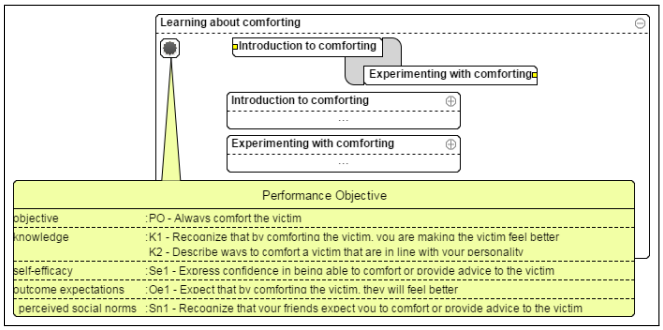

Fig. 3: A scenario with a performance objective 'always comforting the victim' and two sub-scenarios (both detailed in figures 5 and 4)

with IMP (in step 4), its components and their functions should be closely related on the outcome of the IMP process (step 1 to step 3). Stated differently, the serious game should target one or more of the change objectives associated with the performances objectives (outcome of step 2), while using intervention methods and practical strategies identified in step 3 of the IMP process.

The modeling concepts of ATTAC-L can be used to link the narrative to the outcome of the IMP process. This creates two important advantages: first, allowing the designers to verify whether the serious game and the IMP outcomes are in accordance; secondly, automatically providing documentation of the design process as required by IMP and other pedagogical design strategies.

To illustrate our approach, we use the storyline models given in figure 5 and 4. The context of our example is the Friendly ATTAC project [23], which aims to develop a behavioral change program for cyber-bullying based on IMP. One of the program goals is to teach youngsters to understand the concept of cyber-bullying and to react in an adequate way when confronted with cyber-bullying incidents. The scenario that we use in this paper, focuses on the

performance objective described as "comforting a victim after witnessing a cyber-bullying incident". Using IMP, the behavioral determinants and change objectives associated with this performance objective were identified (i.e., the matrix of changes objectives, see table I – we refer to the work of our colleagues [24] for more details about the IMP program developed), as well as a set of intervention methods.

We use the annotation concept of ATTAC-L to specify how the outcome of the IMP process can be incorporated into the narrative model of the serious game, i.e., the performance objectives, change objectives, and intervention methods. This way, modelers (and stakeholders) can clearly identify which parts of the storyline attribute to which performance objectives and behavioral determinants. The annotations also help to determine the connections that exist within the serious game between the developed intervention methods and the narrative.

We start by explaining how the performance objectives and their further refinement into change objectives can be specified for the narrative model. We then do the same for the techniques and strategies of the intervention methods.

A. Linking Performance Objectives and Change Objectives

Pedagogical objective annotations can be used to specify which part of a storyline model is associated with a particular performance objective. For this purpose, we have created the performance objective annotation, which is a subtype of a pedagogical objective annotation that is associated with a scenario (also see figure 2, which provides an illustration of the different annotations and their subtypes dedicated to IMP using an UML class diagram). A performance objective annotation has a set of parameters that define the performance objective and the determinants and change objectives related to this performance objective. In figure 3, an example of such a performance objective annotation is presented. The performance objective is 'always comfort the victim' (see table I). The behavioral determinants that should be influenced by the scenario are 'knowledge', 'self-efficacy', 'outcome-expectations', and 'perceived social norms'.

ATTAC-L also allows the modeler to reflect the refinement of a performance objective into change objectives. A scenario annotated with a performance objective can be divided into different sub-scenarios, each dealing with one or more change objectives and their corresponding behavioral determinants. This means that in each of these scenarios', specific behavioral determinants will be tackled. The scenarios will include intervention methods that affect determinants with the aim of achieving the change objective. Each sub scenario is marked to indicate with which specific change objectives they are dealing. They are annotated with another type of pedagogical objective annotation called a change objective annotation (see figure 2). The sub-scenarios of the scenario 'learning about comforting' used in figure 3 are given in figures 5 and 4. The first one is annotated with change objectives related to the determinant 'knowledge'. It states that the scenario contains intervention methods specifically for increasing the knowledge of the player about comforting a victim. The second one has an analogous purpose for the determinants 'self-efficacy', 'outcome expectations' and 'perceived social norms'. The specification of how and where the intervention methods are used is explained in the next section.

B. Linking Intervention Methods

Intervention methods can be embedded in a scenario in two ways: (1) as game mechanics that are unrelated but complementary to the storyline, guiding the player in a certain way, for example by presenting a popup to the player with extra hints or by giving a positive score after making a correct choice. Or (2) as events expressed directly in the narrative, for example a character demonstrating the correct behavior or giving positive feedback during a conversation.

In order to express an intervention method through game mechanics (method type (1)) designers can use the existing pedagogical action annotations. Recall that pedagogical action annotations are used to specify required actions that have a particular pedagogical intention, such as providing additional information, assistance, or feedback. Different subtypes of pedagogical action annotations have already been defined, like the score annotation that changes a player's score and the assist annotation that gives hints to the player.

To create the link with the change objective, the Pedagogical action annotation has been extended to include an argument that denotes the targeted change objective. Figure 4 shows the use of the score annotation as a method for achieving the change objective 'Se1' (see Table I). Similarly, the same figure uses an assist annotation for linking the change objective 'Oe1' (see table I) to the method of giving hints to the player about the correct choice.

Intervention methods can also be embedded by expressing them as a part of the narrative, e.g., involving characters or showing specific situations that help the player to obtain the intended behavior (method type (2)). To model this we use the existing pedagogical strategy annotation. In this case, the scenario containing the intervention should be annotated as a whole. Since many different intervention methods are possible – each with different characteristics – this annotation type is an abstract one (i.e. we cannot define all of its properties; cf. abstract class in UML). Concrete subtypes, whose properties have all been specified, should be defined for different methods. For instance, the role-model annotation has been defined for the 'modeling' or 'observational learning' principle used in the Social Cognitive Theory (SCT) [25]. This annotation is illustrated in figure 5. In the example, a friend of player 'Nate' shows the correct behavior of comforting the victim. The role-model annotation is attached to the scenario to indicate that the scenario as a whole implements this role-modeling method. The annotation itself contains the parameters to indicate the change objectives it influences ('K1' and 'K2', see table I) and which in-game character is acting as the role-model.

VI. Conclusions and Future Work

In this paper we established a link between the process of pedagogical design based on IMP and the narrative

modeling in ATTAC-L. By combining pedagogical design and narrative modeling, designers can maximize the efficacy of serious games. Furthermore, the integration of elements from the pedagogical design process into ATTAC-L through an elaborate annotation system facilitates the communication between technical and non-technical people. As such, ATTAC-L represents a serious game design tool that enables and stimulates multidisciplinary collaboration.

We showed that relevant outcomes of a pedagogical design process based on the IMP (i.e., performance objectives, change objectives, and intervention methods) can be linked to the story model using corresponding pedagogical annotations. ATTAC-L and its elaborate annotation system allow designers to specify different aspects like learning goals and story flow separately. The clear separation of narrative and educational aspects helps to increase the designers overview of the different elements of the serious game. As a consequence, designers with different expertise can concentrate their attention on particular aspects of the game, while maintaining a clear view of its relations to all others aspects of the game.

Currently, ATTAC-L is used in the Friendly-ATTAC project [23] which applies the IMP to tackle the issue of cyber bullying. Using ATTAC-L, the project team is developing a serious game for youngsters based on intervention methods identified with IMP. The output of ATTAC-L is used to generate parts of the code to help speed up the development process. Thus far, the pedagogical annotations have not been included in the generated code. We believe that it should be the ambition of future research endeavors to develop a standard for transforming the pedagogical annotations into functional coding that can be integrated into the main flow of the serious game code. Another path to consider is the linking between ATTAC-L and pedagogical design strategies other than IMP. We believe that even though the approach presented in this paper focused specifically on IMP, the principles for linking pedagogical design strategies and narrative modeling are generally applicable and therefore provide lots of flexibility.

ACKNOWLEDGMENT

This research is funded by IWT (Institute for Science and Technology)[3] under the Friendly ATTAC project.

REFERENCES

[1] M. Dondlinger, "Educational Video Game Design: A Review of the Literature," *Journal of Applied Educational Technology*, vol. 1, no. 4, pp. 21–31, 2007.

[2] O. De Troyer and E. Janssens, "Supporting the requirement analysis phase for the development of serious games for children," *International Journal of Child-Computer Interaction*, vol. 2, no. 2, pp. 76–84, May 2014.

[3] T. Lim, M. B. Carvalho, F. Bellotti, S. Arnab, S. de Freitas, S. Louchart, N. Suttie, R. Berta, and A. De Gloria, "The lm-gm framework for serious games analysis."

[4] F. Van Broeckhoven and O. De Troyer, "ATTAC-L: A Modeling Language for Educational Virtual Scenarios in the Context of Preventing Cyber Bullying." in *2nd International Conference on Serious Games and Applications for Health*. IEEE, May 2013, pp. 1–8.

[3] http://www.iwt.be

[5] ——, "Specifying the Pedagogical Aspects of Narrative-Based Digital Learning Games Using Annotations," in *Proceedings of the 9th International Conference on the Foundations of Digital Games*. Society for the Advancement of the Science of Digital Games, 2014.

[6] S. Kelly and J. Tolvanen, *Domain-specific modeling: enabling full code generation*. John Wiley & Sons, Mar. 2008.

[7] L. K. Bartholomew, G. S. Parcel, G. Kok, N. H. Gottlieb, and M. E. Fernández, *Planning Health Promotion Programs: An Intervention Mapping Approach*. John Wiley & Sons, 2011.

[8] S. Arnab, K. Brown, S. Clarke, I. Dunwell, T. Lim, N. Suttie, S. Louchart, M. Hendrix, and S. de Freitas, "The development approach of a pedagogically-driven serious game to support Relationship and Sex Education (RSE) within a classroom setting," *Computers & Education*, vol. 69, pp. 15–30, Nov. 2013.

[9] G. Kok, P. Harterink, P. Vriens, O. de Zwart, and H. Hospers, "The gay cruise: Developing a theory- and evidence-based Internet HIV-prevention intervention," *Sexuality Research & Social Policy*, vol. 3, no. 2, pp. 52–67, 2006.

[10] J. Mikolajczak, G. Kok, and H. J. Hospers, "Queermasters: Developing a theory- and evidence-based internet hiv-prevention intervention to promote hiv-testing among men who have sex with men (msm)," *Applied Psychology*, vol. 57, no. 4, pp. 681–697, 2008.

[11] O. De Troyer, E. Janssens, and H. VandeBosch, "How to kick off the development process of a serious game?" in *CHI workshop: Lets talk about Failures: Why was the Game for Children not a Success?*, 2013.

[12] S. Gbel, L. Salvatore, R. Konrad, and F. Mehm, "Storytec: A digital storytelling platform for the authoring and experiencing of interactive and non-linear stories," in *Interactive Storytelling*, ser. Lecture Notes in Computer Science, U. Spierling and N. Szilas, Eds. Springer Berlin Heidelberg, 2008, vol. 5334, pp. 325–328.

[13] S. Weiss, W. Mller, U. Spierling, and F. Steimle, "Scenejo an interactive storytelling platform," in *Virtual Storytelling. Using Virtual Reality Technologies for Storytelling*, ser. Lecture Notes in Computer Science, G. Subsol, Ed. Springer Berlin Heidelberg, 2005, vol. 3805, pp. 77–80.

[14] J. Torrente, A. del Blanco, E. Marchiori, P. Moreno-Ger, and B. Fernandez-Manjon, "¡e-adventure¿: Introducing educational games in the learning process," in *Education Engineering (EDUCON), 2010 IEEE*.

[15] E. J. Marchiori, A. del Blanco, J. Torrente, I. Martinez-Ortiz, and B. Fernández-Manjón, *Journal of Visual Languages & Computing*, no. 6, pp. 443–452, dec.

[16] E. M. Hirdes, N. Thillainathan, and J. M. Leimeister, "Towards modeling educational objectives in serious games," *Pedagogically-driven Serious Games (PDSG 2012)*, 2012.

[17] C. Tran, S. George, and I. Marfisi-Schottman, "Edos: An authoring environment for seriousgames design based on three models," in *4th Europeen Conference on Games Based Learning ECGBL2010*, october 2010, pp. 393–402.

[18] R. Koper and B. Olivier, "Representing the Learning Design of Units of Learning." *Educational Technology & Society*, vol. 7, no. 3, pp. 97–111, Nov. 2003.

[19] J. F. Sallis, N. Owen, and E. B. Fisher, "Ecological models of health behavior," *Health behavior and health education: Theory, research, and practice*, vol. 4, pp. 465–486, 2008.

[20] B. Gransson, J. Gulliksen, and I. Boivie, "The usability design process integrating user-centered systems design in the software development process," *Software Process: Improvement and Practice*, vol. 8, no. 2, pp. 111–131, 2003.

[21] C. A. Lindley, "Story and narrative structures in computer games," 2005.

[22] F. Van Broeckhoven, O. De Troyer, and J. Vlieghe, "Using Controlled Natural Language for Specifying the Narratives of Digital Serious Games," Vrije Universiteit Brussel, Tech. Rep., 2015.

[23] Friendly ATTAC, "http://www.friendlyattac.be/en/."

[24] A. Desmet, K. Van Cleemput, S. Bastiaensens, K. Poels, H. Vandebosch, M. Verloigne, G. Vanwolleghem, L. Mertens, and I. De Bourdeaudhuij, "Mobilize bystanders against cyberbullying among adolescents the friendly attac project." Submitted.

[25] A. Bandura, "Social cognitive theory of self-regulation," *Organizational behavior and human decision processes*, vol. 50, no. 2, pp. 248–287, 1991.

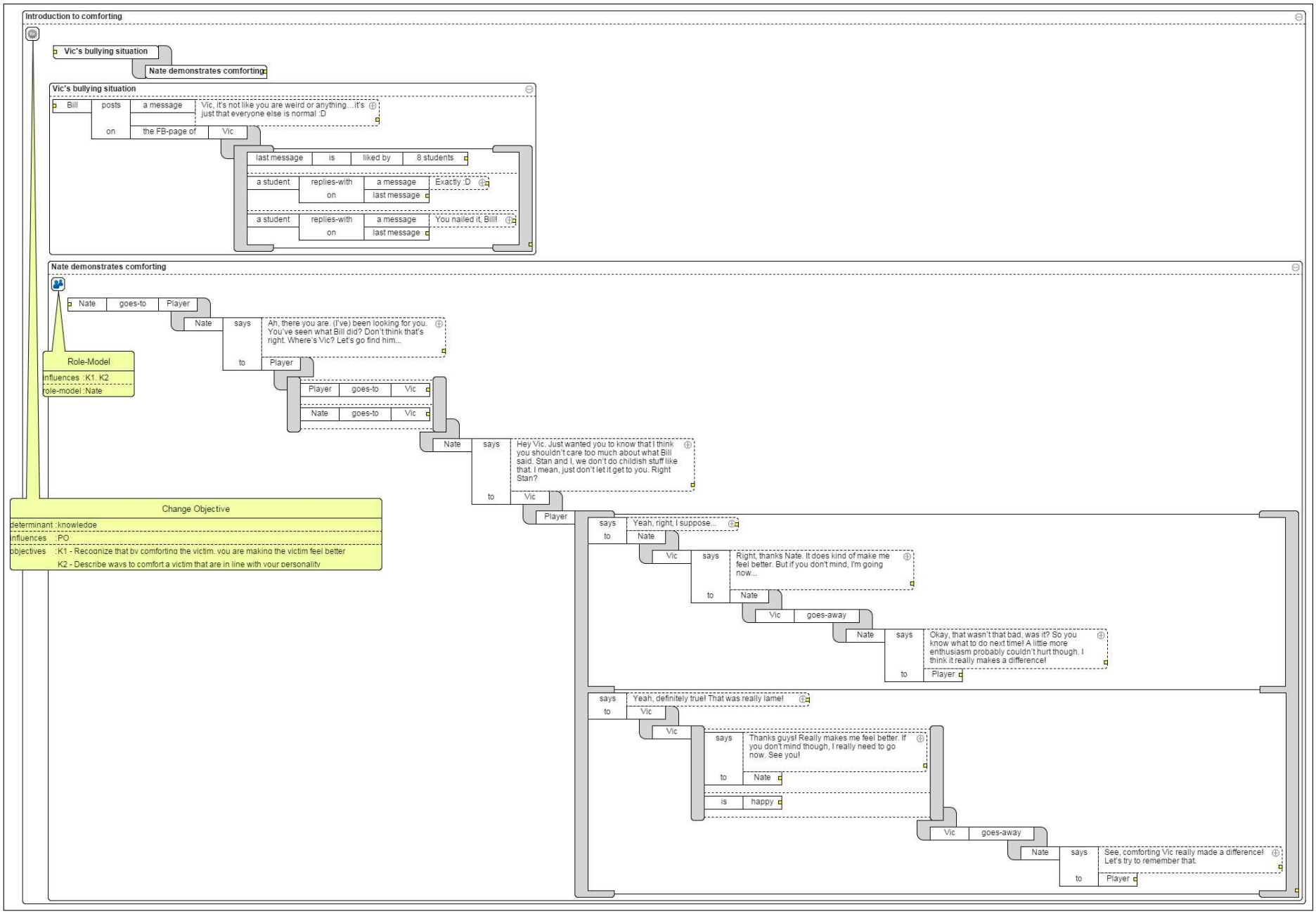

Fig. 5: A scenario with a change objective annotations for determinant 'knowledge' and a ped. startegy annotation for 'role-modeling'.