Designing personalised learning support for K12 education: learner control, motivation and psychological ownership

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Abstract. Digital personalised learning is on the agenda in national educational policy programmes across the world. In Flanders, (Belgium), it is the central goal of the i-Learn programme. One of the educational challenges of this form of learning is to develop pupils with a sense of ownership over their learning. As part of the i-Learn programme, a user-friendly portal is being developed to give pupils and teachers in primary and secondary schools in Flanders access to tools supporting personalized learning. Using educational design research [1], this article presents the first iterative loop in the design of the i-Learn portal. This study gives insight into teacher perceptions on the design of a portal supporting personalised learning, the design conjectures of the i-Learn portal and an evaluation framework for the pilot phase on teacher and learner control, motivation and psychological ownership.

Keywords: personalized learning, educational design research, design conjectures

1 Introduction

Personalised learning – adapting teaching decisions on a macro and micro level to follow an individual learner's needs - is on the agenda in national educational policy programmes across the world [2, 3]. However, personalisation of learning can take many forms, support various priorities and create changes on individual and societal levels, starting from the premise that society needs to put the learner at the heart of the educational system [4]. In many countries, these policies target primary and secondary education and include a drive towards digital education [5]. A critical look shows that these policies address reducing educational inequalities, but sometimes end up creating more [6, 7].

One key dimension of personalised learning – that also proves to be an educational challenge - is ownership and how to engender pupils with a sense of ownership over their learning [8, 9]. Psychological ownership is a construct of a relationship between an individual and a target that the individual feels ownership over, i.e. that "it's theirs" and they have a sense of responsibility towards it [10, 11, 12]. Originating in organizational theory, this theoretical construct explores the extent to which employees feel a sense of ownership over the organization. Dimensions of psychological ownership include (prevention-oriented) territoriality and (promotion-oriented) belonging, self-efficacy, self-identity, accountability and responsibility [13]. Psychological ownership emerges and increases through three routes: controlling the target (control), knowing and engaging with the target (engagement) and investing the self with the target (identity) [10, 11].

Psychological ownership has also been a construct of interest in educational sciences [14, 8], but particularly the notion of control has received much attention here.

Learning and its effects are influenced by a number of learner-internal characteristics (such as prior knowledge, self-regulation and self-efficacy) and learner-external characteristics of the learning environment, and it is here that control plays a role, namely in the extent to which the learner is given control or the extent to which learning activities are teacher-led [15]. Multimedia learning environments and in particular, hypermedia [16] afford more nuanced adjustments for the degree of learner control that is given [15]. This creates a potential spectrum of the amount of control given to a learner, which has led to a distinction being made between learner control, teacher control and shared control [17].

Providing learner control can positively influence the effectiveness and efficiency of learning [18]. However, this effectiveness seems to depend on a number of factors, such as task complexity (e.g. less learner control for procedural tasks [19, 20]), learner characteristics (e.g. learner control mostly benefits students with high prior knowledge or high self-regulation [21, 22]) and the distribution of control and responsibilities over the learner, the teacher and the system. In shared control, there is ideally congruence (i.e. teaching and learning activities are completely aligned with each other) or there is positive friction (i.e. teaching activities are situated in the zone of proximal development of the learner allowing for learning progress) between teaching and learning activities [17]. Learner control also affects learners' self-efficacy, self-determination and feelings of responsibility [23, 24] and seems to work best if it is in line with learner self-regulation skills [17]. Although the effectiveness of learner control has been shown, learning outcomes are low and primarily focused on non-cognitive outcomes [25].

Learner control also encourages learner motivation [26, 27], and for children in K12 education, there is evidence of the influence of learner control on learner agency [28].

Although much work has been done on learner control, the relation between learner control and psychological ownership is less clear. Also, it is unclear how these constructs take shape in K12 education, which is the focus of this article.

What is clear is that the design of a learning environment and how it implements learner control is a defining factor of learner experience and any consequential development of a sense of psychological ownership. Namely, the design determines what the learner can effectively control (e.g. control over (i) sequence of information, (ii) selection of content, (iii) representation of content and (iv) the pace of information

presentation [29]). As actual emergent learner activity is framed by the design [30], how individual learners perceive this control in their experienced interaction with the learning environment (e.g. *perceived* control of (i) technology, (ii) objectives, (iii) content, (iv) planning, (v) design, (vi) access rights, and (vii) personal data) is also important to understand any possible effects on psychological ownership [31].

In the implementation of personalised learning in K12 education, it needs to be understood how the design of learner control encourages or dissuades pupils in developing psychological ownership over their learning. Moreover, the developmental phase in which the pupil is, becomes an additional important factor. It is unknown how the implementation of learner control in the design of a learning environment impacts the development of a sense of psychological ownership over their learning.

1.1 Personalised learning in K12 education in Flanders (Belgium): the i-Learn programme

In Flanders (Belgium), governmental policy in recent years has moved towards personalised learning, supported by technology-driven change. This policy stems from two noticeable phenomena in Flemish K12 education. First, following global trends of aging and migration, diversity in the classroom is also the norm in Flanders [33, 34]. This creates huge challenges for individual teachers and schools to create the best possible educational environments in which each student can grow to achieve key competences, taking into account their individual talents and needs. The low teacher-to-student ratio exacerbate this challenge.

Second, technology offers more possibility to support differentiation in the classroom. However, despite multiple drives for more technology adoption in K12, studies show that mainstream use of ICT in classroom practice by pupils themselves remains relatively low, although the prevalence of ICT in their home life has grown. The ICT competences of pupils seem to be decreasing, in contrast to the perception of their teachers. The use of ICT is also often not integrated into a unified school policy, giving space to differences between teachers [32].

Concretely, this government policy for primary and secondary education takes shape in the i-Learn programme, a partnership between research centers (imec, ITEC), universities (KULeuven, UGent) and educational think-tanks and content providers (RVO Society), in assignment of the Flemish government. The project team consists of researchers in educational sciences and technologies, technology developers, practitioners and project managers. Within the i-Learn programme, digitally personalized learning means learning that takes place in a digital learning environment that adapts to the individual learner in function of optimizing individual and/or collaborative learning processes.

The main goal of the i-Learn programme is to implement digital solutions for personalised learning in Flemish education in a qualitative and sustainable way. Concretely, this will be made possible by providing an online portal where digital tools for personalised learning will be accessible to Flemish schools and teachers, in a low-threshold way. Crucially, i-Learn also aims to provide necessary training and guidance to efficiently use these tools. The aim of the project is to foresee a successful

implementation in at least 10% of the Flemish primary and secondary schools by the end of September 2022 [35].

1.2 Problem statement and Research question

There are many ways in which learner control can be implemented in the designed features of the i-Learn portal to support personalised learning. However, it is unclear which design is most suitable and effective, taking into account learning goals, learner characteristics and learning context.

Literature is unclear about how the design of learner control, in the long term, encourages or dissuades the development of psychological ownership for pupils in K12 education, alongside other constructs such as self-efficacy [36] and intrinsic motivation [37]. It is also unclear which organisational structures are of importance to support the development of psychological ownership in K12 learners, and how these structures can be modelled to support the i-Learn goal of implementing personalized learning in Flanders.

We distinguish three research questions:

RQ1. What are the needs regarding teacher and learner control for a portal supporting personalized learning for pupils in K12 education?

RQ2. How is learner control implemented in the design of a portal to support personalized learning for pupils in K12 education?

RQ3. What are the behavioural indicators of psychological ownership in pupils in K12 education? And related to this, what are the organisational indicators of psychological ownership in K12 classes and schools?

2 Method

The i-Learn programme follows an Educational Design Research (EDR) methodology - a framework for educational research, that takes into account the iterative and practice-oriented nature of design research [1]. Figure 1 presents the generic model of EDR [1] through the three primary phases of analysis/exploration, design/construction and evaluation/reflection, leading iteratively to a more mature intervention as well as ongoing improved theoretical understanding.

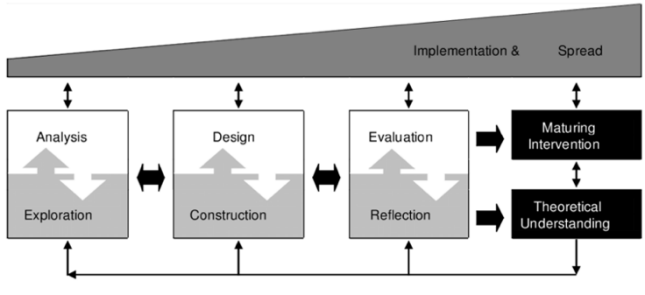

Fig. 1. Generic Model for Educational Design Research [1, p. 83].

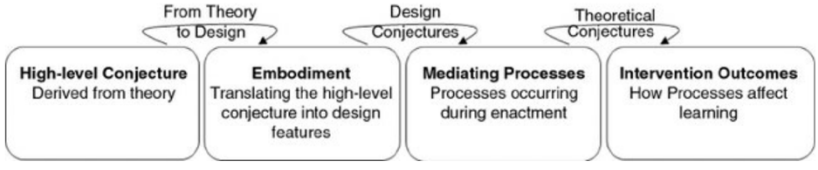

Fig. 2. Generalised conjecture map adapted from [38] in [39, p. 10].

An important part of this methodology is the articulation of design conjectures. Figure 2 illustrates a design conjecture map, a technique that makes explicit which conjectures are derived from theory and embodied in the design, for achieving which outcomes [38]. This article presents the first iterative loop in the design of the i-Learn portal.

We present in brief the research activities conducted in each phase in the loop. More detailed descriptions and analyses of the studies will be presented in future publications. The aim here is to present the flow of theoretical and practical understanding in this EDR project.

Analysis and Exploration Phase. The analysis and exploration phase in EDR [1] was conducted through three simultaneous activities:

First, a literature study was conducted on adaptive learning technologies for personalized learning, to create a typology of adaptive tools. The typology was built up on the basis of common criteria that characterise personalised digital learning, as described by various authors.

Next, semi-structured focus group interviews on personalized learning in school were conducted with 9 schools in Flanders to determine the learning needs to be dealt with in the portal. Each interview was conducted by two researchers. The number of participants ranged from 3-14 and included school principals, teachers, ICT coordinators and school counselors. The interviews were audio-recorded and transcribed. Notes were taken during the interview to gather immediate data, according to a predetermined format, following the time schedule and deadlines of the i-Learn programme. A thematic analysis was conducted on these reports by the lead author in NVivo in the following way:

- First, learning and organizational needs were identified and matched to a target group (pupil, ASS pupil, teacher (exact sciences / humanities), ICT coordinator, care coordinator, parents, school leadership, school-external partnership).
- Next, the identified needs per target group were categorized into larger themes and these themes were labelled.
- Finally, the identified needs were grouped beyond the target groups, so that each identified theme contained needs from the perspectives of different target groups.

For validation, the categorization of needs and the labelling of themes were debated by 5 educational researchers to determine the final set of themes and associated needs per target group.

Finally, a large-scale survey (n= 335) for primary and secondary school teachers in Flanders was organised to gain insight into K12 teacher perceptions on personalised learning and learner needs. The complete description of the methodology and results of this survey would lead too far for the purposes of this article. However, this survey included 4 questions related to learner control (Table 1) which is of interest for this article.

Table 1. Questions related to learner control in large-scale survey (1= not important at all; 5=very important)

Theme	Questions
Teacher perception of the importance of learner control	To what extent are the following elements, that allow **the learner to have control**, important for you to influence the learning process / well-being of the learner at school? (i) level exercises (ii) types of exercises (iii) order of exercises, (iv) number of exercises, (v) instruction of exercises (vi) evaluation of exercises (vii) supervision of exercises
Teacher perception of the importance of teacher control	To what extent are the following elements, that allow **the teacher to have control**, important for you to influence the learning process / well-being of the learner at school? (i) level exercises (ii) types of exercises (iii) order of exercises, (iv) number of exercises, (v) instruction of exercises (vi) evaluation of exercises (vii) supervision of exercises
Teacher perception of the importance of learner access to information	To what extent is the information below **useful for the learner him/herself** to better estimate or improve their learning process / well-being? An overview of: (i) learning content seen and/or exercises made (ii) amount of time spent on particular content/exercise, (iii) results of exercises/tests (iv) fault analysis, (v) progress over weeks/months/years (v) which learning goals/attainment targets (vi) system-feedback and/or teacher feedback

	(vii) planning of tasks that the learner wishes/needs to do and possible deadlines.
Teacher perception of the importance of teacher access to information	To what extent is the information below **useful for the teacher** to better estimate or improve the learning process / well-being of the learner? An overview of: (i) learning content seen and/or exercises made (ii) amount of time spent on particular content/exercise, (iii) results of exercises/tests (iv) fault analysis, (v) progress over weeks/months/years (v) which learning goals/attainment targets (vi) system-feedback and/or teacher feedback (vii) planning of tasks that the learner wishes/needs to do and possible deadlines.

Design and Construction phase. Based on the activities of the analysis and exploration phase, the design of the i-Learn portal was undertaken through a series of workshops with the project team. The workshops were guided by external consultants who were responsible to determine the user stories and system architecture of the portal. A first prototype of the portal is under construction led by a private partner, with piloting expected in the fall of 2020. Once the first design of the portal was definite, a design conjecture mapping exercise was conducted by the lead author in the following way:

- The learning and organizational needs of the portal identified in the previous thematic analysis were mapped to functionalities in portal design and architecture.
- Starting from the key functionalities identified, the most significant and distinguishing design items were pinpointed and named.
- With the design items in place, the design hypotheses from theory and practice were articulated, as well as the mediating processes and intended outcomes.
- Additional targeted literature searches were conducted to support the design conjectures.

Validation of this process was conducted through a debate by 7 educational researchers (3 part of the i-Learn project team; 4 outside of the i-Learn project team). Further scrutiny of the design conjectures was conducted through the individual researchers in the i-Learn project team, who articulated more of the outcomes and added additional design conjectures. This outcome is considered a work-in-progress by the i-Learn team.

Evaluation and Reflection. The last phase in this EDR loop concerns evaluation and reflection. [1] distinguish two aspects to evaluation: (i) research on intervention (i.c. understand how the intervention of the i-Learn portal works) and (ii) research through

intervention (i.e. understand how the phenomenon of psychological ownership relates to other constructs, through the implementation in the i-Learn portal). They also make a distinction between alpha testing (on internal structure), beta testing (use in context) and gamma testing (effects).

In order to prepare this complex evaluation of the piloted prototype (planned late 2020 – early 2021), a targeted literature study has been conducted to create a conceptual model to measure emergent learner activity [30]. The following methodology was used:

- The key themes for evaluation were determined: "learner control", "psychological ownership", "technology-enhanced learning", "K12", "motivation"
- Starting from some key articles ((i) Buchem (2012), (ii) Avey et al. (2009), (iii) Pierce et al. (2001), (iv) Pierce et al (2003)), a snowball method on cited and citing references was used to expand the article set [40].
- Additionally, some targeted literature searches were conducted on the relationship between learner control and psychological ownership in K12, as well as on teachers' transformational leadership in the classroom, resulting in a final set of 29 relevant articles.
- A conceptual model was constructed based on these articles

3 Results

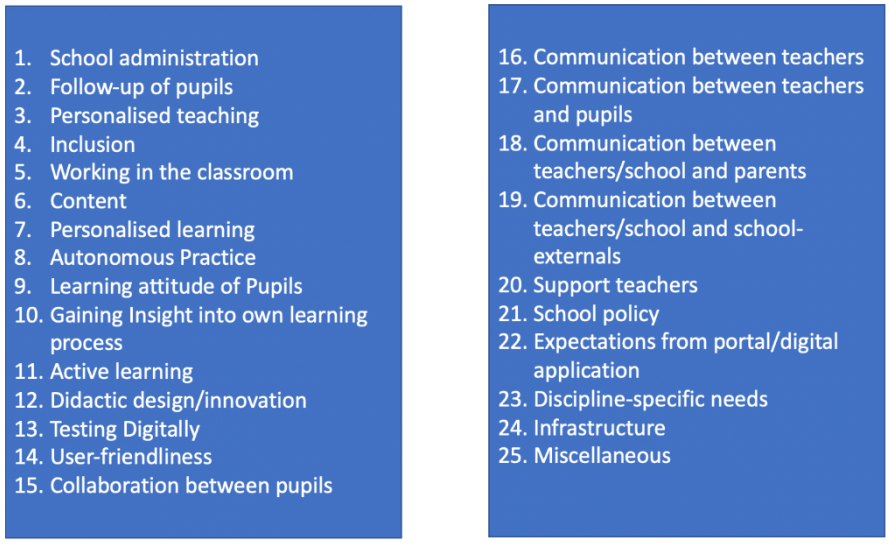

Fig. 3. 25 themes resulting from thematic analysis

Analysis and exploration phase. The thematic analysis of the semi-structured interviews resulted in 25 themes related to individual (learner, teacher, etc.) needs or organisational needs on personalised learning in K12 education (figure 3).

Of these, the most significant needs related to the portal design ánd concerning learner control and/or ownership are the following:

- Learners need to be able to follow-up their personal progress (theme 2, theme 10)
- Learners need to be able to learn according to their own context and own needs (theme 3, theme 7)
- Learners need to be able to choose user interfaces to suit their own needs (theme 7, theme 14)
- Learners need ownership over their own learning paths, but these need to be shaped by the teacher (theme 3, theme 7, theme 11).
- Learners need to be able to determine their own learning goals, and work towards them through relevant scaffolded support (theme 3, theme 7, theme 10).
- Learners need to get feedback on their personal action points to adapt their learning accordingly (theme 3)
- Learners need to be able to plan their own work, and complete this work at their own pace. (theme 8)

However, apart from these, teachers also indicate that they want to retain control over various aspects of learning

- Teachers need to be able to offer qualitative content available in different presentation formats, that is in line with learner needs. (theme 6)
- Teachers need to be able to see the progress made by individual learners, to inform how they design these learners' future learning paths. (theme 3)
- Teachers need insight into which content has been gone through by individual learners, in order to define the next steps for them (theme 2, theme 3, theme 8, theme 9)

The results of the thematic analysis therefore indicate towards shared control over learning activities, between teachers and pupils.

Tables 2 and 3 show the results of the analysis of the four questions on teacher perceptions on teacher learner control and information access to teachers and learners from the large-scale survey.

Primary school teachers find it important to retain more control over the learning activities the pupils engage with. Regarding access to information, they find it important that pupils have insight into the feedback they receive and information related to planning. They do not seem to deem it as important that pupils have access to other types of information such as progress or fault analysis.

Table 2 Primary school teachers' perception of importance of learner/teacher control and learner's/teacher's access to information (n=156; *p<0.01)

	M learner	M teacher	t-test	df
Control over:				
level exercises	3.46	4.48	-11.592*	155
types of exercises	3.42	4.28	-10.628*	155
order of exercises	3.21	3.72	-5.073*	155
number of exercises	3.33	4.05	-9.128*	155
instruction of exercises	3.97	4.29	-4.213*	155
evaluation of exercises	3.76	4.37	-7.363*	155
supervision of exercises	4.11	4.37	-4.410*	155
Access to information on:				
learning content seen and/or exercises made	3.91	4.26	-5.288*	154
amount of time spent on particular content/exercise	3.35	3.86	-5.950*	154
results of exercises/tests	3.99	4.17	-2.661*	154
fault analysis	4.08	4.48	-5.038*	154
progress over weeks/months/years	3.97	4.28	-4.299*	154
which learning goals/attainment targets	3.46	4.27	-8.114*	154
system-feedback and/or teacher feedback	4.14	4.10	0.661	154
planning of tasks that the learner wishes/needs to do and possible deadlines.	4.06	3.94	1.967	154

Table 3 Secondary school teachers' perception of importance of learner/teacher control and learner's/teacher's access to information (n=179; *p<0.01))

	M learner	M teacher	t-test	df
Control over:				
level exercises	3.64	4.23	-7.075*	178
types of exercises	3.59	4.12	-6.899*	178
order of exercises	3.17	3.58	-4.808*	178
number of exercises	3.36	3.80	-5.555*	178
instruction of exercises	3.82	4.17	-4.501*	178

evaluation of exercises	3.86	4.27	-5.320*	178
supervision of exercises	3.88	4.20	-5.171*	178
Access to information on:				
learning content seen and/or exercises made	4.10	4.29	-3.157*	174
amount of time spent on particular content/exercise	3.59	3.84	-3.244*	174
results of exercises/tests	4.24	4.26	-.484	174
fault analysis	4.43	4.41	.584	174
progress over weeks/months/years	4.04	4.14	-1.830	174
which learning goals/attainment targets	3.70	4.30	-6.420*	174
system-feedback and/or teacher feedback	4.37	4.33	.727	174
planning of tasks that the learner wishes/needs to do and possible deadlines.	4.24	4.12	2.426	174

Secondary school teachers equally find it important to retain some control over the learning activities, but the absolute values of the t-tests are lower than with the primary school teachers. This is reflected in the average mean differences for primary school teachers (M = - 0.61) and secondary school teachers (M = - 0.44). Teachers in secondary school however do seem to favour giving pupils access to various sources of information regarding their learning. For results of exercises/tests, fault analysis, progress, feedback and planning, they seem to find it important to give the same amount of access as they themselves have.

In answer to our first research question, we can say that teachers advocate for shared control over teaching and learning activities with K12 pupils, where the learner control is primarily situated on pacing, sequencing, planning and representation control. Teachers prefer to hold control over the selection of content. They view access to information on learning behaviour as an important factor to support personalized learning with pupils in secondary education. In primary education, they prefer to give less control and limited access to information on planning their learning.

Design and Construction phase. As illustrated in Figure 4, ten distinguishing design items were identified, and related theoretical hypotheses were defined.

Two design conjectures were formulated:

1. Personalised learning (i.e. scaffolded support with support contingency) improves student learning [41, 42, 43].
2. Learner control engenders psychological ownership [31, 10].

In answer to the second research question, the design items are a mix of features (i.e. distinctive qualities of the portal) and functionalities (i.e. operations that can be performed in the portal) that give teachers and pupils shared control over different aspects of the learning activities. The same design items fulfil part of both design conjectures. For example, teacher-adapted learning paths together with the student-

triggered feedback and alerts allow for personalised amendment of learning activities towards a set learning goal (conjecture 1), but they also create room for the pupil to take ownership over their learning (conjecture 2) pulling pupil attention to the metacognitive and affective levels.

The last column describes desired outcomes of the design [38] or, which learner behaviour is expected to be achieved through the design. Here, effective student learning on cognitive, non-cognitive and efficiency are the primary expected outcomes.

Fig. 4. Design conjecture map

Evaluation and Reflection. Literature on psychological ownership in the target group of K12 education is very limited, focusing primarily on teachers' ownership and skills [44]. The relationship between psychological ownership and learner control in K12 education seems unexplored. However, the relationship between these concepts can be modelled by widening the scope beyond the K12 target group.

Going beyond the limitation of K12 education, Pierce et al. (2001) identify three routes to psychological ownership: control, engagement and identity. Of these, control has been the primary interest of this article [10].

A number of articles cover the relationship between psychological ownership and motivation, as the same factors seem to influence both concepts (e.g. sense of control; sense of identification with their behaviours). Additionally, Self-Determination Theory suggests that people are naturally motivated to take on more ownership over their behaviours, through internalisation of external motivations, over time [45, 37].

A complex relationship exists between the notion of control and motivation. Sheldon et al. (2003) indicate that in cognitive evaluation theory (part of SDT), environmental information (such as rewards) can undermine intrinsic motivation if these rewards are experienced as controlling (reducing autonomy). An important distinction is made between locus of control (if the *outcomes* one works towards are perceived as determined by external forces or internal forces) and locus of causality (if one's *actions* are perceived determined by external forces or internal forces) (Sheldon et al., 2003). According to SDT, environments that support the three basic psychological needs of autonomy, competence and relatedness allow people within the environment to thrive. Learner control also encourages learner motivation [26, 27].

In literature on childhood education, learner control is also linked to learner agency, and together with choice, support autonomy [28]. The notion of agency is related to volition and intention (thereby strongly linked to the locus of causality mentioned above), and contrasted with structures [46]. Interestingly, Kucirkova (2019) in the Agentic Personalisation Framework, relates higher agency and individualism to personalisation "on the learner's terms". High structure and individualism is related to individualization. Finally, she also includes attachment (building on the psychological property of ownership and bonding) as one of five aspects to personalization.

This creates a mixed picture for shared control: giving learner control can support experienced autonomy, competence and relatedness which in turn support intrinsic motivation and ownership. However, feeling controlled by someone (e.g. in cases of high teacher control) can be detrimental to motivation. In other words, shared control is achieved by finding the right balance.

Perceived control has a positive effect on psychological ownership, which in turn has been shown to be a good predictor of learning effects [14, 31]. Motivation also has a known positive effect on learning outcomes [47, 48].

Additionally, psychological ownership is positively related to various organizational contextual factors. For example, research has indicated the relationship between ownership and transformational leadership [13]. Recent research points to other related constructs that emerge through the organisational setting such as collective psychological ownership, interdependence, team chemistry and work environment structure [49]. Feedback becomes an important indicator here.

Figure 5 illustrates the proposed conceptual model on psychological ownership in K12 education and motivation, and the indicators for these. In answer to the third

research question, the behavioural indicators include perceived learner control, learner agency, learner attachment, and the psychological needs of autonomy, competence and relatedness and motivation. The relationship between motivation and psychological ownership seems to be one of mutual reinforcement. Organisational indicators include autonomy, competence and relatedness support through transformational leadership and the existence of a feedback culture. In learning, psychological ownership and motivation can be non-cognitive learning outcomes that have an impact on cognitive and learning efficiency outcomes.

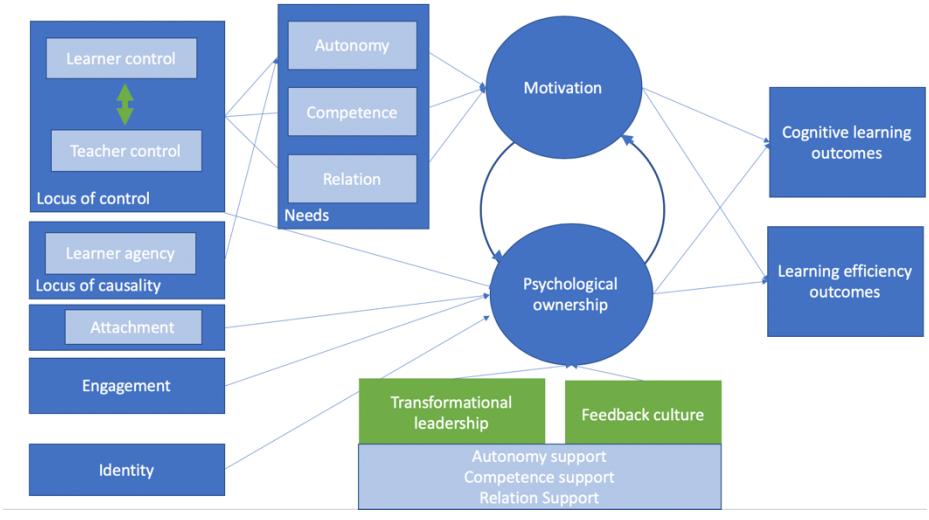

Fig. 5. Conceptual Model for evaluation

Literature also gives some indication for measuring these concepts. Psychological ownership is measured:

- through the *Ownership Measurement Questionnaire*, based on constructs of personal value of the project for the students, student responsibility toward the project, general sense of control of the group project and the effort students are ready to put into the project [50].
- through *Psychological Ownership Scale*, which emphasizes possession as the primary measure [51].
- through a scale developed on the constructs of self-efficacy, accountability, belongingness, and self-identity [13].
- through a scale developed on the constructs of (1) sense of responsibility, (2) sense of self-identity, (3) sense of accountability, (4) sense of self-efficacy, and (5) sense of belongingness [14].

However, these measuring instruments have been set up in diverse ways and also promote an individualized focus of the construct of psychological ownership (as pointed out in [52]). Moreover, none of these measures may be useful within the context

of in K12 education. There are few qualitative measures for the measurement of psychological ownership [53].

In educational contexts, a widely used validated scale to measure the psychological needs are the *Basic Psychological Need Satisfaction Scales* based on Self-Determination theory [37]. Also, underlying constructs such as self-efficacy and self-regulation have also been extensively investigated in this target group. For perceived learner control, there is a scale of measures on (1) control of technology, (2) control of objectives, (3) control of content, (4) control of planning, (5) control of design, (6) control of access rights, and (7) control of personal data [14].

Finally, although transformational leadership is a well-researched concept [54], and several measures exist to measure this characteristic [55], we only found one article that related to the teacher as a transformational leader in the classroom who can influence levels of student ownership [56]. Most articles on transformational leadership in school relate to the role of the school leadership or principle, and concern changes in school organisation.

The development of a feedback culture has also become of more research interest in recent years in organizational and educational contexts [57, 58, 59].

3 Discussion

The EDR methodology used in the design of the i-Learn portal has brought up some interesting results, giving an avenue to create an evaluation framework on learner control and psychological ownership for the piloted prototype.

Regarding research on intervention, the design of the i-Learn portal is built on the central notion of shared control between the learner and the teacher, each with their scope of responsibilities and accountabilities. The design conjecture mapping has revealed the intended mediating processes of autonomy, competence and relatedness and brought into focus the intended outcomes on learner cognitive, non-cognitive and efficiency outcomes. Therefore, evaluation can be situated on how the design items encourage or discourse the development of these outcomes.

Regarding research through intervention, the conceptual model brings some things to consider:

1) Although the exact relationship between psychological ownership and motivation is not clear, the literature suggests that psychological ownership and the concept of motivation are closely related. Therefore, any evaluation of the i-Learn portal with its implementation of shared control needs to take into account the effects on pupil motivation.
2) Although measurement scales exist for psychological ownership, they are limited in scope [52] and do not seem useful for the target group of i-Learn, i.e. learners in K12 education. Measuring psychological ownership of pupils requires a new scale, possibly linked to the current scales on psychological needs (particularly, autonomy) and motivation, originating in Self-Determination Theory.
3) The distinction between control and agency is useful as it nuances the shared control aspect of the i-Learn portal design, discriminating between determining learning outcomes (control) and determining learning actions (causality) [45, 46].

4) The distinction between given/intended learner control and perceived control [14] is useful, especially in the context of K12 education where pupils may not be able to articulate their perspectives due to their developmental stage.

Psychological ownership is also formed by various organizational characteristics and contexts. In particular, the role of the teacher in fostering ownership in personalized learning with pupils will emerge not only through the use of the i-Learn portal, but also through aspects of communication and interaction [60, 61]. The concept of the teacher as a transformational leader in the classroom is therefore useful to capture some of the changes in teaching behavior that the i-Learn portal introduces. Related to this, it will also be interesting to consider how classroom feedback culture develops through the introduction of the portal.

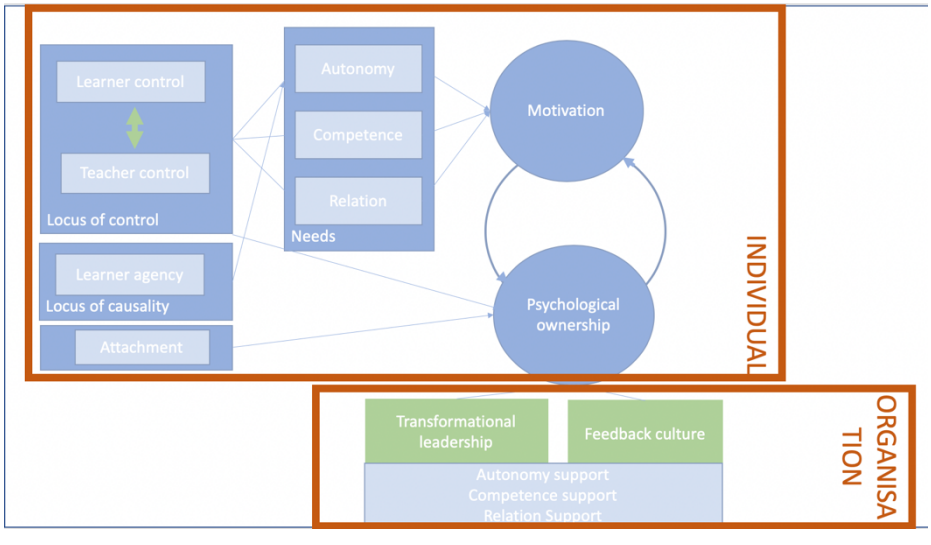

Fig. 6. Evaluation framework for i-Learn portal prototype

Revising figure 5, figure 6 presents an evaluation framework for the i-Learn portal against which both research on the intervention as well research through the intervention can be mapped. For future research, it needs to be taken into account that the extent to which K12 pupils can articulate senses of ownership, self-efficacy, responsibility and accountability needs to be investigated.

4 Conclusion

In this article, we presented the outcomes of the first iterative loop of an educational design research study within the i-Learn programme in Flanders (Belgium), which implements digital personalized learning in K12 education. This study answered three research questions.

Regarding the first research question on the needs regarding teacher and learner control for a portal supporting personalized learning for pupils in K12 education, we found that teachers advocate for shared control over teaching and learning activities with K12 pupils, where the learner control is primarily situated on pacing, sequencing, planning and representation control. Teachers in both primary and secondary education prefer to hold control over the selection of content. In secondary education, access to information on learning behaviour is considered an important factor to support personalized learning with pupils. Teachers in primary education prefer to give less control and limited access to information on planning of learning.

Regarding the second research question on how learner control is implemented in the design of a portal, we identified 10 unique design features and functionalities that together implement teachers' and pupils' shared control over different aspects of the learning activities, within a digital portal supporting personalized learning.

On the third research question regarding behavioural and organization indicators of psychological ownership in pupils, we identified (i) perceived learner control, (ii) learner agency, (iii) learner attachment, (iv) psychological needs of autonomy, competence and relatedness and (v) motivation as the behavioural indicators of psychological ownership in pupils in K12 education. The relationship between motivation and psychological ownership seems to be one of mutual reinforcement. We also found that support for autonomy, competence and relatedness through transformational leadership and the existence of a feedback culture are organizational indicators of psychological ownership in K12 classes and schools. The identification of these indicators resulted in the creation of an evaluation framework for the i-Learn portal, on learner psychological ownership.

In an overarching conclusion, this study has shown that the i-Learn design emphasizes a form of digital personalized learning based on shared control between the teacher and the learner, with a degree of flexibility in the way this is implemented in practice. The design conjectures have made clear that the i-Learn portal has the potential to stimulate learner motivation and psychological ownership in the learner, given the support of certain individual behavioural indicators and certain organizational embedding.

The results of this first iteration following the EDR method feed into the next design loop with some immediate next steps of the i-Learn programme: (i) an evaluation of the prototype (foreseen fall 2020) and (ii) a founded revision of the design of the i-Learn portal. Furthermore, this lays the basis of a critical assessment of the i-Learn programme's strategy and approach to implementing digital personalized learning in Flanders.

We discuss two sets of limitations regarding this study. First, there are some limitations related to the concept of personalized learning for K12 education. We did not focus on personalized learning in a broad sense, but only on personalized learning supported by a digital portal. Moreover, we focus solely on teachers' opinion on the design of a division of control between teachers and pupils in K12 education. However, there are many forms of personalized learning and digital personalized learning, serving many different purposes [63]. The findings of this study may not be generalizable to other forms of digitalized personalized learning. We also focus specifically on K12 education, where the role of the developmental stages of children plays a significant role. The findings of this study may not be generalizable to other target groups, such as

learners in higher education and adult learners. Moreover, this study does not take into account the context in which the digitalized personalized learning (as implemented by the portal) will function [64]. This is relevant, as the actors in personalized learning (i.e. students, teachers, school leadership, scheduling) take on roles and responsibilities with regard to each other, also outside the digital sphere [62]. Digital personalized learning is always part of a larger educational offering and a broader school context [62, 64]. This also contributes to the vision of the i-Learn programme: any evaluation within the i-Learn programme needs to allow for more reflection on the uptake of personalized learning in general. Another related limitation concerns the inherent boundaries of digital personalized learning: the concept suggests that there is a known (often quantifiable) learning goal, and the digital tool supports a learner in working towards such a goal on their own pace and momentum, with visibility on their progress. However, we are aware that this is not always the case in practice: some learning goals are not known at the start of a learning activity, and may emerge as learning activities progress [66]. Moreover, learning goals may not be cognitive in nature, but rather non-cognitive (or a mix of both). Consequently, this form of personalized learning may not be available to all topics and subjects in K12 education, and not be suitable for every teacher's need.

A second set of limitations concern the method we used in this study: the speed of educational design research (EDR) requires continuous deepening of theoretical understanding as well as insights through real empirical data. The methodologies used are in service of the design of a concrete product. In this study, we have focused on the first iteration of design in an educational design research, where we build on scoped data collection and analysis, a rapid prototyping process and a primarily theoretical exploration of psychological ownership and personalized learning. There are limitations related to each of these phases. Regarding phase 1, more in-depth methodologies could be used for the analysis of the empirical data collected given more time. Forthcoming publications will follow with more complete analyses of the empirical data presented earlier in this article. In phase 2 as described in this study, a design methodology similar to a rapid prototyping process has been used to achieve deadlines for product delivery, an often-heard criticism of this design method is that it often tends towards an informal design method [65]. Since then the design has been iteratively improved. Regarding phase 3, this article has described a theoretical exploration of the concepts related to psychological ownership in K12 education based on scoped literature searches, driven by priorities, partially set by design requirements. The tight timing of the i-Learn programme does not always allow for extensively conducted literature searches. As with the previous limitation, more time will allow for more systematic literature reviews of the concepts presented in this work to inform the further steps in this programme. Future research will also focus on the development of instruments for the measurement of psychological ownership and validation of these instruments. The limitations of this study are in many ways typical of EDR, as it is conducted in continuous service of the design of a solution to a real problem [1].

The outcomes of this study have an added value for research on the design of technical environments supporting personalized learning. The use of the EDR methodology has allowed for (i) an targeted exploration and analysis of the context in which such a technical environment needs to function, (ii) a design for such an environment that is rooted in relevant empirical data on the context and enhanced with

relevant theoretical grounding, (iii) a theoretical foundation for the evaluation of such an environment and (iv) last, but not least, articulated relations between these outcomes that enable us as a project team of researchers, practitioners and technology developers to make better decisions concerning the implementation and deployment of the technical environment.

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