Recommendations on Promoting Peer Interactions Within a Future Innovative Distance Learning Device Intended for French Orthodontic Practitioners

Contribution of a Community of Practice Analysis

Aurélie Mailloux
Orthodontics
Reims Hospital
Reims, France
e-mail: aurelie.mailloux@univ-reims.fr

Jérôme Dinet
CNRS, INRIA, Loria
University of Lorraine
Nancy, France
e-mail: jerome.dinet@univ-lorraine.fr

Abstract-**The COVID-19 crisis has changed behaviors and needs of orthodontic practitioners related to (i) cancellation of all the continuing education events, which led to the disappearance of formal and informal exchanges on the practice (ii) emergence of numerous videoconferences, but without any prior identification of practitioners' needs. The problem of interaction within a continuing education online environment is paramount: promoting interaction between peers within the system is essential to (i) reduce the feeling of loneliness (ii) promote users' commitment. Most French orthodontic practitioners were already involved in a virtual active Community of Practice (CoP) with their own way of fostering identification, cohesion, and collaboration. The purpose of this user-centered research is to identify requirements for creating an innovative comprehensive distance continuing education environment that would meet expectations and needs in terms of interactions of most CoP members, according to their experience (novices to experts). After an extensive state-of-the-art, used to better understand the changes in training and education related to orthodontic domain, we conducted (a) a detailed examination of the discursive activities within a CoP (e.g., content, interactions, rhythm, objectives) (b) four focus group (c) a survey consisting of two questionnaires (online, and face-to-face) (d) an ergonomic inspection of the *e-orthodontie.com* website. The collected data confirmed that an innovative complete distance continuing education environment could meet many CoP members' needs, such as: anonymous, scientifically validated content, extensive or limited discussion forums, clinical case sharing, videoconferences instant translation, ease of access and cost and time saving. From a theoretical point of view, this study highlighted the crucial role of the community of practice in producing requirements for creating a useful, usable, and acceptable digital education environment for orthodontic practitioners.**

Keywords-elearning; community of practice; psycho-ergonomic study; innovative device; orthodontics; continuing education.

I. INTRODUCTION

The COVID-19 crisis has changed behaviors and needs of orthodontic practitioners towards continuing education. Among others, the replacement of face-to-face congresses by videoconferences had led to the disappearance of direct formal and informal exchanges between novices and/or experts of the Community of Practice (CoP): the videoconferences current format only allows one-to-one vertical interactions between participants and speakers. However, in the field of distance continuing education, it is necessary to support a form of "e-presence" between members because one of the major dropout factors is the loneliness felt within the education device. Indeed, attrition rate is lower when the user is supported by his/her peers and interacts with them regularly [1]–[3].

The peer discussions on clinical cases could therefore help novices gain expertise (i.e., theoretical knowledge and practical skills) [4]–[6].

According to the state-of-the-art [7]–[10], several solutions are mentioned to promote interactions and commitments within an education distance device, such as distance tutoring, and e-portfolio. However, their results are heterogeneous, and their implementation complex.

This innovative continuing education environment is addressed to French orthodontic practitioners who are mostly already involved in an informal active virtual CoP, built on Facebook© in 2014. In 2022 February, this CoP was gathering almost half of the French orthodontic practitioners. The purpose of this user-centered research is to analyze requirements to promote interactions within an innovative learning system based on a dual approach. On the one hand, the CoP discursive activity was assessed quantitatively and qualitatively, and on the other hand, the CoP members' needs were identified by conducting four focus groups, a survey (which was carried out face-to-face and online), and an ergonomic inspection of the *e-orthodontie.com*, a dedicated website for orthodontic continuing education, although underused by practitioners.

The remainder of this paper is organized as follows. After a state-of-the-art (Section II), Section III describes the data gathered and methodology applied in three different studies to identify the CoP members interactions needs and attitudes according to their experience (novices to experts). This is followed by an overview of findings in Section IV, categorized by the discursive analysis, the CoP members interaction needs and the requirements. Section V

summarizes the value of these findings and outlines elements of future research to be conducted on the subject.

II. STATE-OF-THE-ART

We conducted an extensive state-of-the-art to identify (i) the possible benefits of designing an innovative distance learning device in the orthodontic domain (ii) the current solutions to promote interactions within distance education.

A. Interest of a "demand-pull" approach

The design industry has evolved from a "technology-push" to a "demand-pull" perspective [11]. It is now commonly known that the supply does not create its own demand because:

- from the designer's point of view, the actual uses were often disappointing
- intended and actual uses did not match
- actual uses are sometimes very heterogeneous [12]–[14].

Our user-centered design research is in line with this approach. Indeed, this study consisted in analyzing the practitioners' needs, expectations, and behaviors in terms of (i) continuing education, (ii) interactions and upstream of the design phase.

B. Contribution of an innovative device

The COVID-19 crisis has changed behaviors and needs of orthodontic practitioners. The need to shift the traditional format to remote access is now widely shared. The COVID epidemic has greatly accelerated this trend related to cancellation of all the continuing education events [15]–[17].

The state-of-the-art [11]-[18][30][31] demonstrated that many devices dedicated to the continuing education of dentists or orthodontists have been created over the past 20 years, particularly in Anglo-Saxon countries. These devices were a source of satisfaction for the participants and effective in terms of learning and acquisition of skills but they were mainly centered on one unique theme (e.g., recognition of oral pathologies) and were not focused on the orthodontic discipline [18][19]. However, an innovative complete distance continuing education environment could have many advantages, such as flexibility, lower costs, no office closing and accreditation by the French body of Continuing Professional Development (CPD) [20]–[24].

C. Existing distance learning device

According to the state-of-the-art [11]-[18], there was no complete distance learning environment adapted to the French orthodontic practitioners' needs. Only two complete websites dedicated to distance continuing education were intended for orthodontic practitioners: the World Federation of Orthodontists (WFO) and the *e-orthodontie.com* websites.

First, the WFO website, with online videoconferences access and its smartphone application (with notifications), is the most complete digital continuing education environment available to date, particularly concerning the diversified content, supports, and the scientific validity. Despite this, none of the interviewed practitioners were registered with WFO probably because this device was neither adapted (i) to their expectations and attitudes (ii) nor to their way of interacting with each other. Correlation between cultural and/or social dimensions with the use of a distance education device has already been highlighted in a previous study [25].

Second, the French *e-orthodontie.com* website has been created in 2007 without any prior user-centered research to assess practitioners' needs and expectations [19][20]. That could explain why this website was very little used by French orthodontic practitioners. This is evidenced by the fact that the activity in the forums section was close to zero.

D. The interactions within the devices

According the state-of-the-art [29], the loss of peer-to-peer interactions was the major drawback of the current distance education experiences for participants. That is why interaction represents one of the main issues to be considered for the design process. Nevertheless, several solutions are mentioned in the literature to create a kind of "e-presence" within the distance device, such as (i) virtual small groups of practitioners sharing same centers of interest or geographical proximity [27] (ii) creation of a collaborative e-portfolio [11][12] or (iii) tutoring [9][10]. But interactions between novices and their teachers *via* an e-portfolio were often limited, because, among other factors, teachers considered the digital feedback as a waste of time [11]. Concerning the remote tutoring, it remained generally underused because users struggled to meet their "ideal" tutoring model [9][10].

There are difficulties to maintain mutual commitment and trust in an online environment, hence the importance of examining the interactions within a current active CoP for creating a useful, usable, and acceptable digital education environment for orthodontic practitioners. We considered that an innovative distance continuing education environment, supported by the CoP members (and vice versa), could promote users' commitment. We based our approach on the horizontal social learning theories [3]-[6].

E. Contribution of a community of practice analysis for education device design

Several research-actions involving the design of training devices, in particular digital ones, are based on the notions of professional community in the education fields [33][34].

Nevertheless, CoPs case studies are very rare in the health sector and focus more on the education field (e.g., learning in a school context) [34]. One reason being that CoPs in the health sector (i.e., traditional and virtual) are fewer, less structured and often informal, therefore difficult to identify [35][36].

However, horizontal exchanges between peers represent an important source of cohesion and group identification within the CoP [1]–[6][21]. Besides, learning results from the interaction with other individuals and particularly with peers [3][4].

F. Definition of Community of Practice

First, the community of practice is defined by a common interest for a domain (this is what distinguishes CoP members from non-members) [41]. Second, a community, unlike project-focused teams, endures over time. The CoP

members discuss, help each other, and share information in their fields. Third, they develop a shared repertoire of resources on their common practice: experiences, stories, tools, ways to handle issues. It is therefore by developing these three elements (domain, community, practice) that a CoP can grow and endure. The concept of communities of practice (CoP) is based on the idea that all individuals have always expanded their knowledge by discussing their practice with others, on a daily basis [42].

The social dimension of learning is therefore fundamental for understanding communities of practice [43]. Moreover, among the different types of communities (e.g., of interest, learners, epistemic) and working groups (e.g., project team, functional), the community of practice involves the strongest cohesions and interactions between its members. Regular interactions between peers within a CoP promote (i) mutual commitment, (ii) the emergence of a common project and (iii) the development of a shared repertoire. Exchanges have different values and purposes (e.g., learning, cohesion, identity affirmation). Some elements can either promote participation (e.g., trust, recognized expertise) or discourage it (e.g., fear of judgement, absence of answers, long delays). To last, a CoP must find a balance in interaction dynamics: nature, quantity, and rhythm.

Virtual learning communities have been on the rise in the past decade. Exchanges within these virtual communities are more fluid and faster than in traditional ones. However, they raise specific issues such as privacy, data security and the difficulty to create a user-friendly climate along with enabling confidence between the members [44].

G. Experts and novices

The Dreyfus model (Fig. 1) illustrates the five-phase trajectory from novice to expert including the intermediate stages (i.e., advanced beginner, competent and proficient) [45]. The process also involves several cognitive shifts ranging from the strict adherence to rules with lack of independent judgment, to deep contextualized intuitive understanding.

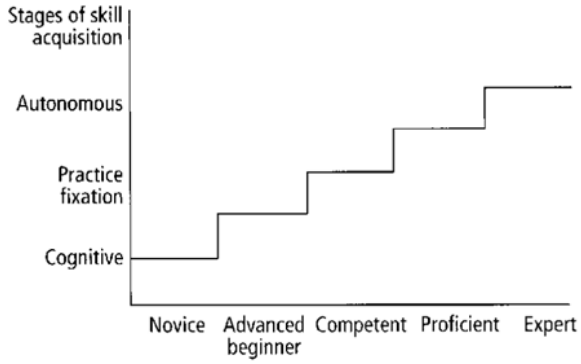

Figure 1. The 5 stages of learning within a CoP.

Learning paths vary depending on members' quest for personal and professional identity. The key focus is to find out their own way of becoming a "practitioner". This learning process is reflexive and built through access to heterogeneous practices and visions, which structure a real "landscape of practices" [39].

H. Community of practice and learning

The current remote videoconferences are based on the traditional vertical "teacher/learner" scheme. However, it is commonly accepted that a social learning environment is essential to foster adult education [46]. CoPs support their members' professional training by sharing their issues or experiences [47]. The resulting discussions from shared clinical experiences could help novices gain expertise by developing their ability to (i) analyze a new clinical situation, (ii) identify its consequences, (iii) adapt their behavior and (iv) consider other points of view [34][40][41]. Promoting peer interactions and encouraging them to share clinical issues are essential in theoretical and practical discipline such as orthodontics. This could help novices articulate these aspects [48].

III. DATA & METHODOLOGY

To produce design recommendations on creating a useful, usable and acceptable digital education environment for orthodontic practitioners, three techniques have been used (Fig. 2). First, we observed the interactions and discursive activities within a virtual CoP "discutons entre spécialistes (let's discuss among specialists)". Second, we conducted four focus groups to identify behaviors related to continuing education, their needs, and expectations. Third, we carried out two surveys: one was addressed to members of a virtual CoP online and a second questionnaire survey was administrated during a congress, to collect data about attitudes and expectations towards continuing education. Figure 2 illustrates the adopted methodology and its objectives.

Figure 2. The triangulation of our methodology.

A. Focus group

Four focus groups with 4 to 6 CoP novices were carried out: three focus groups were conducted before the health crisis and one after. The process was conducted in three stages:

(1) Identification of the difficulties, obstacles, and prospects of continuing education.

(2) Presentation of an existing French training system: the website *e-orthodontie.com*, to evaluate the participants' perception of digital training tools.

(3) Co-construction of "an ideal" website architecture dedicated to continuing education.

B. Questionnaire Survey (online and face-to-face)

The online survey was conducted among practitioners, members of a virtual CoP. The electronic survey was prepared and distributed by the software Limesurvey© to all CoP members, first on January 11, then on January 25, 2022 (n=59 CoP members, including 41 CoP experts and 18 novices).

This online survey was conducted to identify:

(1) Reasons for which practitioners became members.

(2) what the CoP actually provided for its members.

(3) The members status: novices or experts.

In this study, CoP novices were defined as either orthodontic resident (i.e., already qualified in dental medicine) or practitioner with less than three years of clinical experience. CoP experts were defined as orthodontic practitioners with more than three years of clinical experience.

The face-to-face survey was set up during a professional congress (n=42 practitioners, including 23 experts and 19 novices). The design of the questionnaire focused on the following items: current practices, digital uses, obstacles, success criteria of a training experience, opinions on distance continuing education and the vision of continuing education for the future.

C. Examination of a virtual CoP

The dual purpose of this examination was (i) an identification of the current interactions and (ii) description of the discursive activity (in term of content, nature of exchanges, objectives, rhythms, comments and likes generated, etc.) according to their experience (expert vs novice) within the CoP. This enables to study the discursive activity (e.g., rhythm, type of interactions, content within this CoP) and to identify the needs, attitudes, and expectations of the CoP members according to their experience (expert vs novice).

Qualitative discursive analysis enables the distinction between the different digital forms of interactions. Indeed, these revealed different level of participation, commitment and profiles of active members [49]:

- "Passive" digital participation includes document and posts reading
- "Active" participations, (i.e., contributions) includes:

o Non-verbal reactions (e.g., *likes*), specific to digital speech.

o Links, emojis, emoticons, which imply a higher level of participation (either consensus or controversy elements).

o Verbal contributions (e.g., publication of photographs, videos, or the writing of a publication, a question, an opinion). Their authors are considered as central and active CoP members.

On this basis, we examined the posted clinical cases (11 out of the 59 published in September 2021) and the peer comments and reactions. Qualitative analysis of peer comments was carried out using an existing quality grid (for content) [40] and on identified studies of digital discourse (for typology) [46] [47]

This qualitative analysis allowed us to (i) describe finely their forms and content (ii) edit some recommendations to encourage qualitative interactions that foster learning and members commitment.

D. Ergonomic inspection

The *eorthodontie.com* website (also presented during focus groups) was the subject of an ergonomic inspection, to determine if this interface was suitable for the practitioners [26]. We applied the ergonomic quality criteria developed by Bastien and Scapin. They organized the recommendations in the form of categories of ergonomic criteria such as: guidance, workload, brevity, explicit control, adaptability, error management, homogeneity/consistency, significance of codes and denominations, behaviors and compatibility [50]–[52]. This approach is based on the implicit idea that a digital device which meets these criteria is deemed adapted to the end user. The twin objective of this ergonomic inspection is to (i) understand better the reason why this website was little used by French orthodontic practitioners and therefore (ii) to edit some ergonomic recommendations toward the future design of an innovative device.

E. Data analysis

The focus group and the online survey data were analyzed as follows:

The textual analysis was carried out using free software IRAMUTEQ based on the R software and the Python language. After a manual thematic analysis, several automated analyzes were applied and in particular (i) the Reinert Descending Hierarchical Classification (DHC) model (ii) the Factorial Correspondences Analysis (FCA) and (iii) the similarity analysis. The DHC made it possible to divide the statements into classes marked by the contrast of their vocabulary. We completed DHC with a FCA which enabled us to observe the classes "geographical" proximity or distance. We also applied the similarity analysis when the number of segments was insufficient to obtain a saturation of the statements. We analyzed together the first three focus groups data (conducted before the health crisis), to compare them with the last focus group data (conducted after the health crisis). We also compared the online survey collected data between experts and novices (41 experts and 18 novices) to identify their common or divergent expectations and benefits of becoming member of a CoP.

The CoP posts and comments were analyzed as follows:

All posts and interactions (in the form of comments or likes) of the month of September 2021 were subjected to a

thematic content analysis to group them within categories /themes. The nature of the exchanges (e.g., copresence, cooperation, collaboration, identification), correlated with different contents and levels of interaction, have been studied in accordance with Proulx's taxonomy [53]. Interactions level was measured as the sum of comments and/or likes of each publication (low: < or= to 10; medium: > to 10 and < or = to 20; and high: >20).

We analyzed the comments (i.e., categories, feedback type and specific application) generated by clinical case posts based on an evaluation grid of the "quality" of peer comments, produced in a previous study [5].

The face-to-face questionnaire collected data were analyzed as follows:

R studio analysis software was used for all statistical analyses. A *p*-value of less than 0.05 was chosen as the minimum significance value.

Two univariate analyzes were carried out according to age and years of experience.

The Welch test made it possible to evaluate the covariance between several quantitative and qualitative variables with several modalities. For example, the number of days devoted to continuing education, between several groups (i.e., novices and experts).

The Khi2 test provides the means to compare the distributions of a categorical variable (e.g., obstacles to following a training course) between several groups (e.g., novices and experts). When the Khi2 application conditions could not be met, a Fisher's test was performed.

IV. Main Results

A. Contribution of the ergonomic inspection

If the main objective of this website is to train practitioners based on interactivity (the site presentation specifies: *"interactive site of orthodontics, presentation of clinical cases, photos, videos and medical forums. Orthodontic training guaranteed!*"), it is struggling to meet its stated goal.

A descriptive approach made it possible to measure the current activity of the *eorthodontie.com* website, by relying on the "forum", "articles" and "downloads" sections. The census of "forum" activity (Fig. 5) revealed that the publication activity was sporadic and generated very few interactions (compared to the Facebook© discussion group "Let's discuss among specialists"). The *eorthodontie.com* website also seemed more active with patients than with intended end-users (i.e., orthodontics practitioners). Indeed, the most recent discussions in the "forums" section mainly concerned patients undergoing orthodontic treatment who were seeking another opinion.

The interaction, therefore, appeared to be very limited because:

- the only answers came from a single moderator,
- there was no discussion between practitioners,
- the last posts dated more than three months ago.

Forum activity (date of census : 2022-03-09)		
Forum titles	**Date of last publication**	**Number of responses**
patient issues	22/12/2027	0
around a clinical case	24/11/2021	1
ideas or requests	01/11/2021	0
The corner of orthodontics	06/09/2021	0
general discussion	01/05/2021	1
presentation of newcomers	07/01/2021	0
junior doctors	09/07/2019	0
events	20/03/2014	0

Figure 3. Table summarizing the activity (date of last publication and responses) of the available discussion groups.

The ergonomic criteria inspection revealed that:

- Overall informational density was too high
- Immediate feedback was well respected
- Workload was increased due to the lack of brevity and conciseness and the high number of unnecessary actions
- Certain procedures were unnecessarily too heterogeneous
- Readability could be improved

The interface adapted very little to the user's experience and there was no error management. Regarding the content, it lacked completeness, updating, and was not sufficiently scientifically validated. This website examination emphasized the importance of (i) respecting the ergonomic criteria during the device design and (ii) conducting a preliminary practitioner needs assessment.

B. Need for "e-presence"

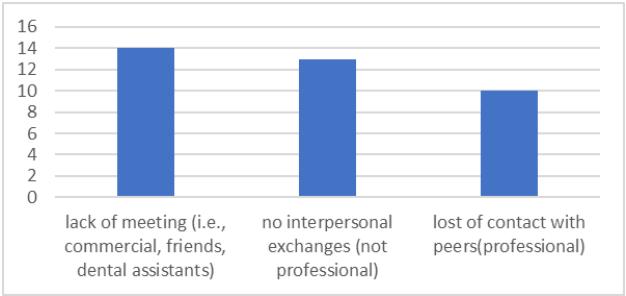

Figure 4. Main disadvantages of distance learning mentioned by practitioners in the questionnaire survey (number of occurrences in descending order after manual thematic grouping).

According to the state-of-the-art, the loss of contact with peers as well as the lack of meetings and exchanges were the main distance learning disadvantage for CoP novices and experts interviewed (questionnaire survey collected data) [54] (Fig. 3). The Welch test highlighted that for younger practitioners (Fig. 4) the decision to participate in a face-to-face congress was correlated with the presence of a close member (*p-value*: 5.366e-09), probably because of their peripheral position within the CoP.

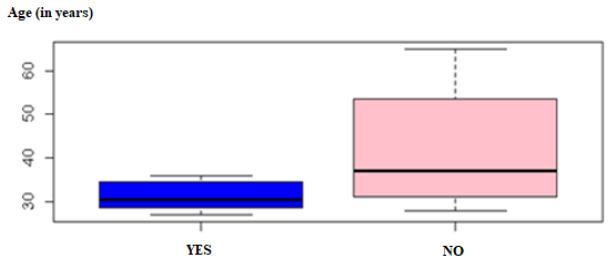

Figure 5. Boxsplot representing the importance of the presence of a close person to attend a training according to the age of the participants.

These results confirmed the importance to consider the problem of remote presence in the device design.

C. Contribution of the virtual CoP discursive analysis

This innovative continuing education environment is addressed to French orthodontic practitioners who are mostly already involved in an informal virtual CoP, built on Facebook© in 2014. This virtual active CoP "*let's discuss among specialists"* (in French: discutons entre spécialistes) has significantly grown these last years. The growth of the informal virtual CoP these last three years (see Fig. 2) seemed to be an underlying trend (i.e., +170% members since 2019). Indeed, the first COVID-19 lockdown (i.e., start date 03/17/2020) did not seem to have modified this growth. In 2022 February, this CoP was gathering 1082 practitioners, representing almost half of the population (i.e., 2420 orthodontic specialists).

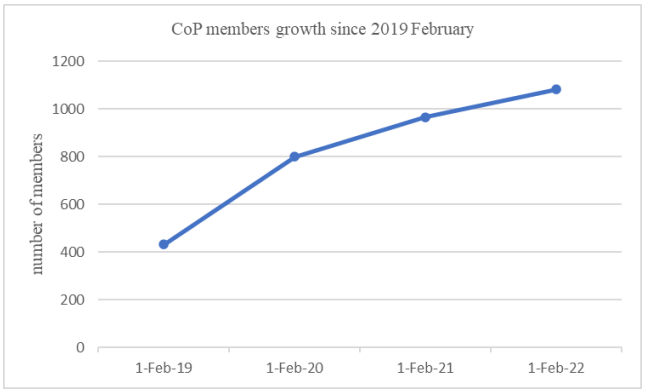

Figure 6. CoP growth since 2019.

The analysis of the publication's rhythm in September 2021 (n=59) revealed its cyclical aspect (see Fig. 7). The analysis of the authors' status showed that the start of a new cycle of publications coincided with a publication by a central CoP member (i.e., moderator, administrator, or recognized expert): their role was crucial in maintaining and developing the interaction

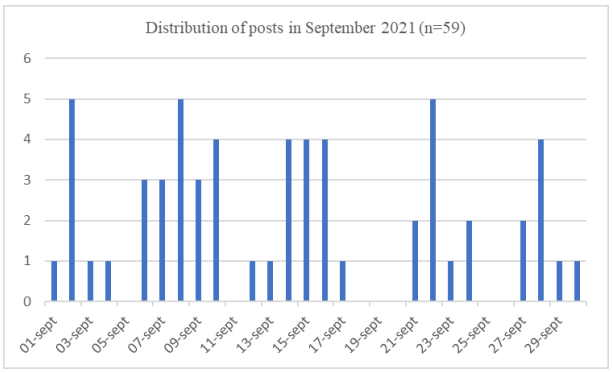

Figure 7. Distribution of the posts in September 2021.

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Number of publications, interactions level and type after thematic classification (n=59 on september 2021)			
Thematic / *sub theme*	number	interaction level *(low, medium, high or inconstant)*	Interactions type *(none/comments and/or likes)*
Co-presence (n=24)			
job ads	3	low	likes
training information	8	low	likes
sale of practice	5	low	likes
patient communication	1	low	comments/likes
patient transfer	6	low	comments
link to other CoP	1	none	none
Cooperation (n=18)			
product/equipment advice	7	medium	comments
HR/legal advice	11	medium	comments
Collaboration (n=14)			
sharing of clinical cases	11	low or high	comments/likes
clinical tips	3	medium or high	comments/likes
Identification (n=3)			
ethical problem	1	medium	comments
criticism of private training	2	high	likes

Figure 8. Publications thematic analysis and the level of interactions generated.

Figure 8 shows the publications thematic analysis and the level of interactions generated. Most publications were of the order of co-presence among members, creating few reactions (mostly *likes)*. Their content were mainly informational. Publications on the mode of cooperation were less frequent but generated a higher level of interaction (mostly *comments*). The collaborative publications, generating a sustained interaction (i.e., clinical cases and clinical tips) were also rarer. During the month of September, three publications with strong identity value were published (i.e., one ethical problem and two criticisms of private training). These elicited many reactions (*likes* or *comments*).

However, all CoP members did not publish in all categories. The publications allowing either reflection on the

orthodontics practice or collaboration among members, came exclusively from the CoP core experts, administrators, and moderators. The novices never participated in the form of posts or comments and very rarely in the form of likes. This observation is consistent with the data collected by focus group: all CoP novices (pre and post COVID-19 focus group) expressed their fear of being judged by the CoP experts. That was indeed the main barrier to their participation [5][37]. It is for this reason that anonymity was such a strong novices' expectation.

Themathic analysis of clinical posts (n=11 on september 2021)			
Thematic/*sub-theme*	number	interaction level	interactions type
Requested concerning a rare pathology	5	low	comments
=>*including referring practitioners*	2	low	comments
Sharing of successful clinical cases	4	high	comments/likes
Requested concerning complex diagnoses	2	high	comments/likes

Figure 9. Shared clinical cases detailed thematic analysis.

Figure 9 shows that practitioners never shared failures or treatments incidents, although this was an explicit strong request from novices, according to post COVID-19 focus group collected data.

The analysis of the 11 clinical contributions allowed us to carry out thematic groupings. The peer reactions and comments were correlated to the topic.

- Four clinical contributions were "well-ended" clinical cases (treated by an innovative technique). These generated a variable number of comments, mostly in the form of likes, but also, thanks, encouragements, or requests to use the same technique. They were published only by the active and recognized CoP experts.
- Two contributions were requests for help with a complex diagnosis or treatment plan. The peers' comments were numerous, and their form diversified: link to videos, photographs or links to other published cases, articles, *etc.* They sometimes gave rise to (i) debates (between active CoP experts only), (ii) searches for a consensus (iii) discussions on corollary subjects (e.g., techniques, devices) (iv) expressions of support toward peers (i.e., the author or other practitioners)
- Two were requests regarding regional issues (e.g., search for a genetic reference center near the practitioner), generating few reactions (i.e., likes) and comments.
- Three publications about rare clinical issues (rare pathologies or technical complex situations). This category generated few comments, in the form of sharing clinical experience, purely informational (i.e., no request)

The description of the peer comments was carried out using the evaluation grid edited by Ortoleva & Bétrancourt (2016) and allowed us to make the following observations:

• The 11 clinical cases were exclusively posted by active CoP experts.

Among these 11 clinical cases, none could be considered as "failed" or "treatment incident". However, the novices interviewed in the focus groups clearly expressed their expectation of publishing treatment incidents as well. According to the literature, sharing these failures represents an excellent source of learning [5].

• None of the peers' comments were personal clinical situations, they referred only to "imaginary" situations or previously published clinical cases.

• As of the two complex clinical cases, only experts discussed the best way to handle the situation. This is the category in which we observed the most (i) discursive precautions, (i.e., politeness) and (ii) diversified supports (e.g., link to other clinical cases, videos, training).

• From a formal point of view, concerning the readability, intelligibility and exhaustiveness of the comments, these criteria were well respected.

D. Impact of the COVID-19 crisis on the CoP members learning needs

The comparison between the focus groups data collected before *versus* after the health crisis enabled us to describe finely the changes of continuing education perception, raised by the literature [15]–[17]. Regarding the interactions, in the pre COVID-19 focus group, the lack of informal exchanges between peers was a significant barrier to distance learning. The "ideal" learning experience was a face-to-face conference, with limited costs and duration. In contrast, in the post COVID-19 focus group, the" ideal" learning experience consisted in clinical cases sharing (i.e., especially failed treatment) illustrated step by step, anonymous, internet-based literature search, scientifically validated content, and videoconference instant translation into French. The need to translate was strong for CoP novices, probably because they were afraid of misunderstandings without being able to detect them. The health crisis changed deeply the practitioners' perception toward distance learning (Fig. 10). According to the literature, an innovative complete distance continuing education environment could henceforth meet many CoP members' needs [21][22][23].

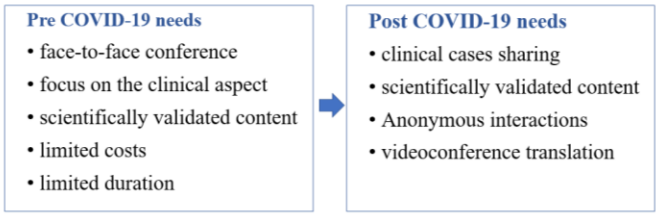

Figure 10. Evolution of experts and novices' needs after the COVID-19 crisis

E. Experts/novices: interactions attitudes, needs, and expectations

The distinct similarity analysis produced from novices and experts' responses to the online survey, allowed us to

distinguish their expectations and needs towards the CoP. Figure 11 shows two different profiles in terms of content, interaction needs and attitudes within the virtual CoP "*let's discuss among specialists"*. The experts expected to (i) be informed about the novelties, (ii) discover the practice and clinical tips of their peers. Their main goals were to evaluate their own practice and eventually modify it: that was a reflective learning process based on reciprocity. Concerning novices' needs, they expected to obtain expert opinions and were in an observant attitude.

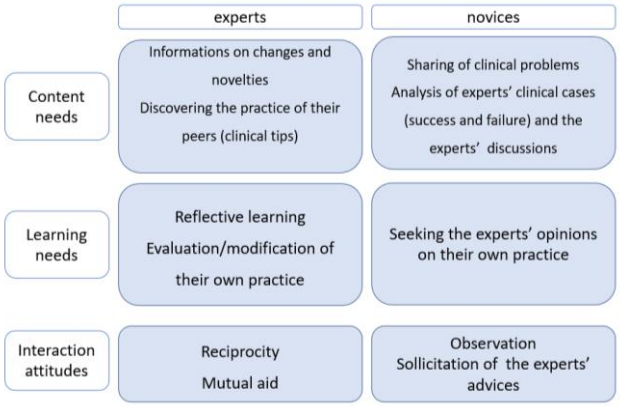

Figure 11. Experts and novices' needs in terms of content, learning and interaction.

F. Interest of being member of a CoP

According to the online survey collected data, the reasons why practitioners become members of a virtual CoP depended on their status.

For the novices, the members of a virtual CoP was mainly looking for a "network" and "professional announcements". The verbs "to share", "to obtain opinions" and "to see" which accompanied the notion of " clinical cases". For the novices, the added value of being a part of a virtual CoP was "to see others' clinical cases" and "to discover their peers' practice". This highlights to the importance of interactions and sharing practice for their professional development. These results were consistent with the observational posture of novices within a CoP.

As of the experts, the members of a virtual community of practice were mostly looking for "what's new", "tips and tricks" and to "help each other". The recurring verbs associated with the notion of "clinical cases" were "to learn" and "to exchange".

Concerning this group, the interactions take place based on reciprocity, which is consistent with their more central position within the CoP.

G. Interaction quality improvement

To improve the efficiency of the practitioners' comments in terms of learning and collaboration, a participation charter could be draw up, according to the peers' comments quality evaluation grid [32]:

• By specifying the rules of participation (e.g., use of a friendly tone), this charter could encourage the participation of novices who were afraid to be judged by the CoP experts.
• It could improve the "quality" of peer discussions by encouraging them to (i) share personal clinical cases, (ii) come up with questions, (iii) make suggestions, (iv) share scientific articles. That could indeed promote learning and address the needs of novices.

The publication of recommendations for speakers could allow videoconferences to meet (i) the expectations of CoP members, (ii) and comply with recommendations for good practice. These suggestions could encourage them:
• To cite scientifically validated articles.
• To be exhaustive and up-to-date.
• To focus on daily practice and clinical aspects.
• To answer questions from practitioners.
• To produce a bibliography to deepen the subject.

H. Several requirements to promote peers' interactions

The current virtual CoP via Facebook© did not allow to create small discussion groups, nor to publish anonymously. An innovative continuing education environment should offer these possibilities to encourage novices' participation and ultimately stimulate interactions between peers. According to the state-of-the-art and our collected data, some criteria should be respected to promote practitioners' participation:

First, participation in discussions forums could be done under a pseudonym. However, each practitioner's status should be known (novices/experts), so that novices could trust in the posted information.

Second, the content scientific validity could be ensured by various means:
-Review by known International/European clinical experts.
-Review by teachers from universities.
-Review by a mixed college (universities teachers and clinical experts).

Some of these experts should also be involved in facilitating the forum and take on the role of moderator to promote the interactions, as in the virtual CoP "*let's discuss among specialists".*

Third, the device should offer the possibility of exchanging on his/her clinical cases via a forum, seeking the opinions of other practitioners or even having access to very detailed clinical cases (step by step).

Fourth, the device should allow the creation of limited or extended discussions groups based on professional status (expert/novices). The geographical discussion group could also be relevant according to the CoP discursive analysis: 2 of the 11 clinical posts were indeed requests for referring practitioners in the same region (see Fig. 5).

Finally, active (e.g., contributions, likes, emojis) and passive (e.g., reading content) participations are valuable to build trust between members. In the Facebook virtual community, passive participation is not known, yet passive participation is essential for authors to be aware of being

read. Thus, to value the passive participation, the number of views for each post could be visible

V. DISCUSSION

The collected data (focus group, online survey, virtual CoP examination) agreed and complemented each other. This confirmed the interest of adopting a data triangulation method to formulate relevant recommendations [56].

Although learning within a CoP is a trajectory from novice to expert passing through intermediate stages, the data analysis conducted by dividing them into two groups (novices vs experts) allowed us to reveal different attitudes, needs and expectations in terms of continuing education.

It is commonly accepted that novices participated less than experts, because of their peripheral position within the CoP [3]-[6]. However, an education device should encourage all CoP members to participate on a voluntary basis, to reduce the feeling of loneliness and foster their commitment [4]. But, if virtual CoPs share the same principles than traditional ones (e.g., commitment and mutual trust), this is more difficult to maintain in an online environment [57].

Our collected data explained more precisely why the WFO and the *e-orthodontie.com* websites did not match users' expectations. Concerning the WFO website, there was a strong language barrier: in all focus group, the need to translate everything into French was commonly shared. Concerning the French *e-orthodontie.com* website, the content was perceived as not scientifically valid by interviewed practitioners. Moreover, this website was accessible to patients, specialist, and non-specialist orthodontic practitioners. This "open access" was the subject of numerous criticisms by all the interviewed practitioners. In addition, these websites did not qualify for Continuing Professional Development credits.

In addition, the virtual CoP "let's discuss among specialists", although active and growing, is struggling to involve novices despite expressing a significant need to share their clinical cases and their "failures". Furthermore, the impossibility of forming small discussion groups and the lack of anonymity seem to hinder their participation. However, this sharing of clinical cases on the part of novices and the solicitation of peer comments on them could help them better articulate the practical and theoretical dimensions of the discipline. Moreover, the clinical cases presented by the experts are above all very complex diagnoses (never failures, etc.) or successful clinical cases but whose treatment management deviates somewhat from the recommendations.

All surveys revealed indeed the significant tension within this CoP related to the various academic backgrounds (specialists versus non-specialists). The open or limited access of non-specialists to the innovative distance learning environment should be carefully considered: the specialists considered the non-specialists as an outgroup of the CoP, whereas the non-specialist probably considered the specialists as experts of the CoP.

This paper showed that orthodontic practitioners commonly needed (i) scientifically validated content, (ii) extensive discussion and limited groups, (iii) anonymous, (iv) publications on clinical cases (successful AND unsuccessful). These results were consistent with the state-of-the-art. But contrary to the literature, in our study, the discussion forums group should be centered on the professional status (CoP novices and/or experts) and not on the center of interest [27].

It would have been interesting to carry out focus groups of CoP experts, but professional constraints (solitary practice, geographically scattered, lack of time) prevented us from doing so. Nevertheless, the online survey enabled us to include mostly CoP experts. The experts were numerous either because they participated more actively into the CoP, and/or because they were more represented there.

We conducted this user-centered psycho-ergonomic study by limiting the notion of users to practitioners who need to be trained and not to speakers and/or trainers/facilitators/tutors who provide resources and/or animate the CoP. However, it would seem necessary to identify the needs of all the actors to promote the acceptability of the system. It would therefore be interesting to extend this work by evaluating the different stages of design by the different actors.

VI. CONCLUSION AND FUTURE WORK

A complete, careful analysis of the orthodontic practitioners' needs, expectations, and interactions behavior within the virtual active CoP *"let's discuss among specialists"* was done for this innovative distance environment to comply with the criteria of usability and acceptability.

According to our data collection, a comprehensive distance learning environment could meet many novices and experts' expectations. Indeed, the CoP novices reported their need to (i) interact with experts anonymously (to avoid being judged), (ii) create restricted or extended online discussion, (iii) ask for questions about all available content (e.g., videoconferences, articles), and (iv) be informed of news by notification. The needs and attitudes of novices and experts we described in this study are supported by the data on the CoPs [1]-[6], particularly concerning cohesion, sharing of experiences and identity needs. However, the way to proceed is specific to each profession and, to our knowledge, no previous study has analyzed the orthodontic practitioners' community.

This research revealed that discussions on the posted clinical experiences constituted the CoP added value perceived by its members and helped novices articulate the theoretical and practical dimensions of orthodontics. As such, the sharing of clinical experience must be encouraged in the future system

This study allowed us to identify the CoP members needs and expectations in terms of (i) content (and the categories structuring it), (ii) expected interactions between novices or

experts (e.g., rhythm, themes, anonymity, etc), (iii) scientific validity, (iv) sharing or observing the peers' positives or negatives clinical experiences. Our findings indicates that (i) COVID-19 crisis modified the CoP members learning needs and (ii) the interaction needs, attitudes, and expectations of CoP novices and experts were different. On this basis, several requirements in term of interactions and contents have been proposed.

This users' center research showed that an innovative education environment would greatly enrich the CoP, particularly in terms of content, support, and variety of possible exchanges. All focus groups participants co-created a website architecture and discussed their expectations in terms of supports and contents to design an "ideal" distance learning device. The contents and supports will be the focus of a future article.

Our user-centered approach must be extended during the design/redesign phases by empirical methodology at different stages without and /or with "real" users, to ensure compliance with the device ergonomic criteria [58]. In the next phases, the concept of users should encompass lecturers and facilitators.

The security and legal standing of shared medical data such as X-rays and/or photographs of patients' needs to be addressed. Further studies on the security aspects of the device are also important to be conducted to minimize the risks of malicious attacks and gain more confidence from the practitioners.

Further experimentation should be conducted, including more in-depth investigation of practitioners' expectations during the post COVID-19 period to justify usefulness of the proposed requirements.

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