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WalkAbout – A net-based interactive multiuser 3D-environment for enhanced and engaging learning

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***Abstract*—This paper presents the current and ongoing research and development of WalkAbout, a distributed and open virtual world application for enhanced and engaging learning. Using WalkAbout, teachers and learners can engage in active learning using different 3D-environments online, where learning and education can be conducted. The environment allows learners to represent themselves using many different avatars, animations, expressions paired with traditional voice communication. More classical presentations are done using one or several virtual web screens that allow users to bring outside content into the virtual world. Another aspect presented in the paper is how gamification can be used to enhance the learning using missions, points and challenges. The paper also discusses aspects of using a commercial game development engine for a non-game application and discusses possible future directions for how an open world learning environment online can be further developed and be used in other scenarios.**

Index Terms*—*Active learning, Collaborative learning, Computer game technologies, Educational technology, Gamification, Learning systems.

I. Introduction

Online and net-based learning [1] has been used for education in technical programs at university level since the 1990's and in Swedish academia one popular system was mStar which was developed during the 1990's [2] where large groups of students and teachers could interact in real time using audio, video, chat, web, whiteboard etc. The mStar system was commercialized under the name Marratech starting 1998 and the technology was acquired by Google in 2007.

Today, much of the synchronous online education is done through real-time video conferencing tools such as Zoom [3], where students meet the teachers through primarily scheduled lectures. Here typically only the teachers send video, and the big mass of students are just anonymous name tags with a few interacting via chat and/or voice.

At the same time, several alternatives have emerged. Second Life is one 3D-environment that has been used for learning online [4]. Examples of modern popular environments that can be used for online teaching and learning include Gather [5], a browser-based group interaction service and AltspaceVR [6] primarily designed for interaction in virtual reality.

During 2019-2021, the authors developed a tool called Dialogica [7] with the primary target of helping people with special needs (e.g., aphasia) express themselves in a playful gaming environment using avatars, animations, text and voice chat and so-called philosophical conversations [8]. Dialogica was developed as a computer game environment using the game engine Unity [9] primarily for iPads. See Figure 1 for an example view of Dialogica.

Figure 1: The Dialogica application.

Dialogica is an application for a specific purpose, and during testing and usage, the idea of making it more generic emerged and the idea of WalkAbout was conceived as a generic learning environment building both on the long experience of developing distributed learning environments online and the more recent work with Dialogica.

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WalkAbout gives teachers and learners an alternative to traditional online education where they can interact in a fun and engaging way in an enriched environment [10]. In this online environment, the learners can practice active learning [11] [12] and become more active in their own learning instead of just being passive learners. Through active learning, the students achieve a higher level of learning through increased cognitive absorption [13]. This follows the pedagogical idea of Luleå University of Technology of active learning [14] in education.

This paper presents the currently ongoing research and development of the WalkAbout interactive environment for education and learning.

II. WALKABOUT

WalkAbout is an experimental application for group interaction designed for education and learning and is developed as a computer game environment using the commercial game engine Unity [9] with both mobile and desktop devices as targets. In WalkAbout, users can interact in different 3D-environments using animations, movement, text and voice chat.

When the application is launched, the users can either create a new room or join an existing room from a room overview (see Figure 2). Here they can see how many users are currently in each room and how many seats are available in that specific room.

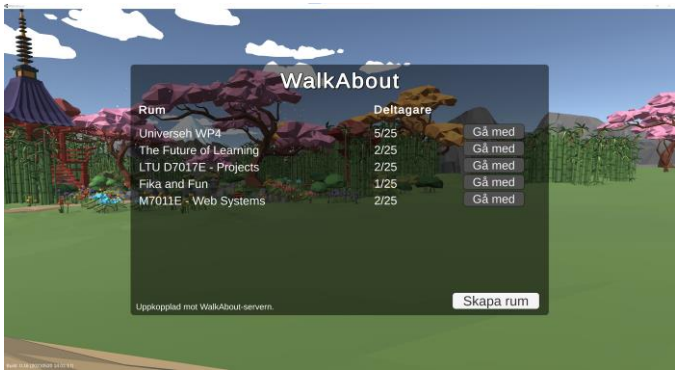

Figure 2: A room overview.

A. Movement

In the various available worlds, the users can move around freely by walking, running, jumping and rolling. The users can also do a special super-jump to help them move high up or longer distances quickly. See Figure 3 for a view of the movement user interface on a mobile device.

Figure 3: Interaction in WalkAbout on a mobile device.

Users can via the participant overview jump to other players positions and/or fetch one or all participants to their current position. The latter is useful when a teacher wants to gather all participants in the same place in the world (see Figure 4).

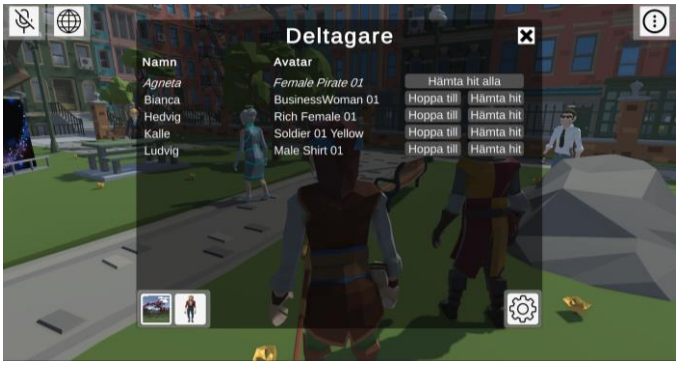

Figure 4: The participant overview.

B. Self-Expression

In real life, humans are constrained when it comes to physical self-expression to e.g., our body language, how we communicate verbally and how we dress and accessorize. In virtual environments, the same constraints do not exist and in WalkAbout, users/students can express themselves via hundreds of different avatars of different styles, some human like and some more fantasy oriented such as skeletons and robots (see Figure 5).

Figure 5: A selection of avatars that the users can choose from.

Users can further express themselves via various animations to show feelings, interests or more whimsical movements like dancing or playing virtual instruments like guitars or the drums (see Figure 6). Students can e.g., lean back while listening, look around to show disinterest, or just do various things such as dance, run in circles, jump around and much more.

Figure 6: Avatars showing different animations in the Sci-Fi world.

C. *Communication*

Users can communicate using real-time audio, much like most other conferencing tools with one difference. In WalkAbout, the audio is 3D-positional, meaning that the further away from the speaker a user moves the lower the volume will be, just as in real-life.

The 3D-positional audio can be used to create a form of break-out rooms where users can have conversations in separate groups at different locations and speak openly and at the same time see the other groups nearby. If a teacher wants to visit a group and listen in, they won't just show up, but the students can see the teacher approaching, just as if they were separated into groups in a physical room.

Various visual cues to show the range of audio are planned and being able to lock the audio inside e.g., a half sphere like a cover over the speaking area. This would give the users better feedback on who can hear them and block others from eavesdropping.

Furthermore, private voice conversations can be held using a direct channel between two users without them having to be close to each other.

D. *Presentations*

Presentations are usually a central part of the teaching and learning experience.

In WalkAbout, users can spawn web screens to simulate more traditional learning environments with a presentation area (see Figure 7). These web screens can be created where the user is looking and are not constrained to specific places. Students and teachers can create their own presentation areas by how they place the virtual web screens. As this is a virtual environment, the presenters can use any number of presentation screens and not be constrained by a physical room setup.

The presentation screens are full web browsers and can thus show anything that can be shown in a normal browser including various web presentation tools, videos, PDF-files or web pages.

Figure 7: Three web screens and three avatars in the Western world.

The audience can choose to zoom into the presentation to get it full screen and not have to see the other participants' avatars. Control of the presentation is done via buttons in the user interface or using a physical keyboard.

E. *Inclusion*

To make the application more inclusive, special care has been taken with the choices of available avatars, different skin colors, clothing, character size, accessories and non-human forms such as robots, skeletons etc. Another aspect of inclusion is language, and the user interface is designed to be primarily icon based.

The chat interface allows for messages to be translated in real-time to other languages as well as being read out loud using text-to-speech generation. This allows for real-time

communication between teachers and students with different backgrounds without having to rely on English only as a common language. In Sweden this might not be a big issue, but in other countries where children do not study English from a young age this helps to cross the language barrier and helps the learners in their learning situation.

Currently the written parts of the user interface are in Swedish, but internationalization is ongoing, and it will be possible to add new interface languages via automatic translation to many different languages.

F. Graphical Profile

The graphics and look and feel of WalkAbout were picked to create a playful feeling. The graphics are blocky, but at the same time high resolution. The reason is to open the users' imagination instead of making it as real as possible. See Figure 8 for an example of the City world.

Figure 8: The City world.

At the same time, new graphical environments can be introduced easily. See Figure 9 for an example of a digital copy of the university library at Luleå University of Technology that is planned to be added to WalkAbout.

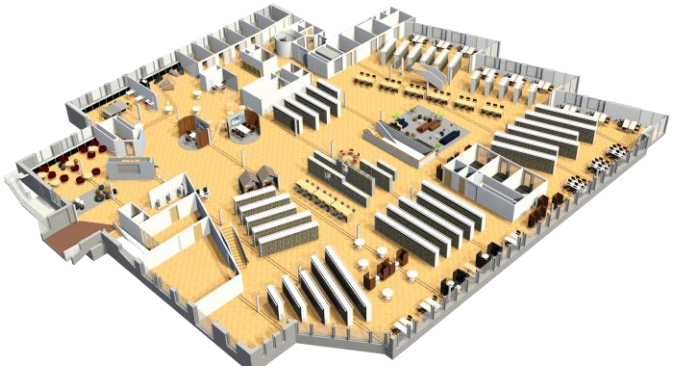

Figure 9: Example of a model of a real-world environment, the university library at Luleå University of Technology.

III. Learning Scenarios

WalkAbout can be used for various learning scenarios and in this section four different scenarios are presented.

A. Live Lecture

The live lecture scenario allows one or several presenters to give a lecture to an audience (see Figure 10). The presenter transmits audio just as in a normal online lecture together with one or several virtual screens for slides. The audience can show interest by moving around, sitting down, wiggle their legs while watching or show disinterest by walking away or showing an animation indicating disinterest such as looking around or running in circles.

Figure 10: Lecture scenario with web screens in the Japanese world.

The presenter can structure the presentation area as they like, with any number of screens placed on ground level or up in the air. The actual lecture place might be selected to be on the ground or e.g., up on a rooftop in the city, inside a medieval dungeon or in a space colony.

The 3D-positional audio allows listeners to show full attention by standing close or placing themselves further away to indicate that they are only listening "with one ear". The 3D-positional audio also allows for several simultaneously ongoing presentations, if the presenters are far enough from each other.

B. Prepared Student Presentations

A variant of the live lecture is that students can prepare their presentations in advance, much like a poster session at a conference. The presenters choose a spot in the virtual world, where they create presentation areas using one or several virtual screens.

When the presentation starts, the audience e.g., students in a class easily move their avatars to the current presenter via the participants view or the presenter can move everybody to them. Compare this to having groups of students walking around in a physical room to see other students' presentations.

C. Informal Interaction and Spontaneous Meetings

An important part of learning is to be able to discuss what you have learned with others and help others learn. Presenting what they have learned to other learners is an important part of active learning [11] and according to the ICAP framework it is an interactive form of learning [15] which is the most important level.

In WalkAbout the participants can move around and have spontaneous and informal interactions. Other students that pass by an active discussion can overhear what is being said and join into the discussion if they want.

D. *Ask Questions*

The fourth scenario is asking questions. This scenario ties into all the other scenarios and here a student can indicate that they have a question by raising their hand via one out of several different animations. The answer can then come from either another active participant, a student or a teacher.

A future direction is using automated entities, so called bots or non-player characters to help students find the answer to their questions. This is further discussed under VII Future Directions.

IV. Gamifying Education

Gamification is the process of using computer game elements in non-game contexts [16] and it can be used on various levels to influence people's behaviors. When moving education to an online virtual environment, the step to using gamification as part of the education is not far away. In WalkAbout, gamification can be used in various ways and in this section several possible usages of gamification are discussed.

A. *Missions*

Give the learners missions to solve. These missions are presented as separate goals in an overview and automatically ticked off when they are solved. A teacher would create the missions and in the same world several different missions might exist, and the learners might choose themselves in which order they would like to solve the missions.

The missions might be presented directly to the learners as they join a specific room or they could be spread out in the virtual world where the learner must look for them, much like in an open world game. Where the next goal is placed can be indicated by a light beacon, i.e., a pillar of light that shines into the sky and can be seen all over the virtual world.

The missions could also be time limited, e.g., must be solved within a certain time frame or on that specific day.

B. *Points*

When the learners solve the missions or other tasks, they might be awarded points. These points can be presented in high score lists to promote individual competition or they could be presented on a group level. The advantage of the latter is that both stronger and weaker learners can contribute to the group's success while on an individual level the weaker learners might have a hard time reaching the top.

The points can also be used as part of an assessment process outside of the virtual world. E.g., the learners might use the points towards a final examination where the points are calculated towards the final grade.

The points can also be used to unlock new functionality, much like in many games where new parts, levels, items etc. are unlocked as the user/player progresses through the game.

C. *Challenges*

Users might challenge other users to compete in quizzes or different timed challenges related to their current course.

The challenges might be global, inviting everybody in the current virtual room to attend, or it could be that the one that responds first is the one to join. It could also be based on position in the virtual world where two or more users meet near a quiz-table and start the challenge together. Other users that pass by can stop and watch the progress.

D. *Make it Fun*

A big part of creating engagement in learning is to have fun while learning. In WalkAbout, fun can be many things including chests and containers with different *toys*, e.g., fireworks, paint guns to color the environment, modification tools that allow the user to change the ground and buildings, stickers, drones, items that change the avatar temporarily, mini games or even horses or cars for moving around (see Figure 11).

Figure 11: Avatar riding and different horses.

E. *Daily Activity*

The idea of missions and awards can be combined into daily activities and score streaks. Learners that login into a course room will get rewarded for just being there. Of course, just being there won't give them credits towards formal assessment, but instead will be in the form of fun things. Score streaks means that the user gets rewarded for signing in over consecutive days.

This is used in many games and is a game element to increase user presence and activity. The daily activity hopefully means that learners interact more in the world and when they are in the room also engage in more learning activities.

V. Implementation

This section presents specific implementation details of WalkAbout.

A. *Using a Commercial Game Engine - Unity*

WalkAbout is implemented using a commercial game engine, Unity. This has both advantages and disadvantages.

Compared to a more traditional software development environment, the advantages are numerous and include handling of 3D-environments, animations, character controlling, 3D-positional audio and advanced lighting among others.

Using Unity, several different platforms can be targeted with little extra effort. WalkAbout is currently being developed for desktops and laptops with Windows and MacOSX and mobile devices with iOS, but more targets can easily be added.

Using a computer game engine, other interaction forms such as augmented, mixed or virtual reality can be added as well. Without using a game engine this would have been harder to achieve.

Another advantage is that many packages with various functionality exist, both for free and commercially. These assets consist of graphics, character controllers, sound effects, network engines, animations, development tools and much more.

A disadvantage of using packages/assets created by others is that they need to be updated in the WalkAbout project due to both new functionality, which can be postponed and more importantly bug and security fixes which might need to be fixed urgently.

Another disadvantage is that there is no high-level common user-interface library meaning that the user interface itself does not conform to platform specific user interface guidelines. Instead, the developers need to create and design their own user interface. This is quite typical for computer games, where each game has its own look and feel but for more standard applications a more homogeneous user interface experience might be expected from the users.

The advantages of using a commercial game engine for developing an application such as WalkAbout outweighs the disadvantages.

B. *Networking*

WalkAbout is a distributed application where the overall state is handled by a server-component. This server-component keeps track of all the changes in an authoritative way to give a consistent experience for all members including updating late-comers and distributing data to all other clients as well as making it harder to cheat in the environment. The server-component itself is part of the WalkAbout-application, i.e., when WalkAbout is installed and run each instance can be both a server and client in the same application.

The application allows for multiple rooms to run at the same time and the servers for handling server information are built with reliability and redundancy in mind where several servers collaborate to deliver the best experience. In short, this means that if one room server goes down, another server is available to take over. As it is only room information handled here, the network load is very low.

For the actual room real-time data, each client, as mentioned above can act as a server including the mobile devices. This allows for a scalable solution while at the same time keeping resources down. The data forwarding is very light weight and only the weakest clients might have trouble handling the data. Currently, there is no handover to other servers implemented and this is a clear disadvantage and thus both dedicated servers for handling data and automatic handover to a new server will be implemented in the future. For larger deployments this is a requirement to get a stable installation.

WalkAbout is a distributed application targeted towards both small and large groups. Using Unity, it is easy to change the network functionality and currently the network protocol KCP [17] is used for data transport. KCP is a lightweight protocol for reliable transport on top of UDP which is faster than TCP. This is important when using WalkAbout over connections where data might be lost as KCP allows for a faster retransmission of lost data.

C. *Control – The Social Protocol*

In mStar/Marratech much of the control of what happened in the rooms was relinquished to users in what was called *the social protocol.* While most current conferencing applications implement a level of control with host/member functionality, where the host hands out permissions to other participants, the social protocol instead relies on that the users can behave properly in a distributed environment online just as they would in a physical classroom.

For higher education scenarios, the social protocol is fine in most cases (compared to a Zoom-session where everybody has all the rights), but in some cases, e.g., with younger children a higher degree of control is needed. WalkAbout will support having different roles where a teacher can limit the functionality of other members in a session. This functionality is currently implemented in the Dialogica application and will be migrated to WalkAbout.

VI. Evaluation

WalkAbout has not yet been used in real teaching situations as it is in a proof-of-concept development state right now. The current prototype has been presented and discussed with both active students and teachers in several workshops where valuable feedback has been gathered. Preliminary findings include that the students look forward to alternative online learning tools where they can represent themselves in new ways and experiment with education and learning.

The plan is to test WalkAbout for education starting spring of 2022 and WalkAbout will also be tested and used in the UNIVERSEH project during 2022-2023 for cross-European higher education. UNIVERSEH is a *European Universities* initiative promoted by the European Commission [18].

WalkAbout will also be evaluated as a general tool for distributed groups, where it might increase the feeling of presence.

VII. Future Directions

The research and development of WalkAbout will continue during 2022 and this section presents possible future directions.

A. Other Use Cases

Even if much focus is on higher education, WalkAbout can be used in other scenarios as well including:

1) Other Forms of Education

Besides higher education, WalkAbout will be used in compulsory school environments to help children learn.

A special case is to help new immigrants understand how a Swedish school works by creating virtual environments that resemble real school environments. The children can learn together with adults how their school works and how they are expected to behave. Here the real-time translation of chat and spoken word will be useful to bridge the initial language barriers as well as real-time translation of the user interface to new languages. The latter is functionality already available in the Dialogica application.

2) Work

In a post-pandemic work environment, many employees will work in a mix of at work and at home environments. Using a virtual environment, they can signal to their colleagues where they are working currently, and what they are doing without the tool being too intrusive on their privacy. The idea is that using a tool such as WalkAbout, the group would get a higher level of feeling of presence.

It is also possible to take it even further to have WalkAbout running 24h/7days per week where everybody can see what the others are doing. In mStar, this was called the eCorridor where users were sending video 24/7 as even an empty chair was conveying information about that user. This could be intrusive and instead using virtual avatars, more users might be inclined to use the tool for a longer time period. I.e., going from a single meeting online mode to persistent mode.

3) Social Scenarios

WalkAbout could be used for social interaction in general, where users use the tool for social interaction like parties and live concerts (like in the game Fortnite).

The tool can also be used for virtual recruitment events that are popular at universities where visitors can walk around in the virtual environment and interact with other users, listen to presentations, ask questions and much more.

In the end, WalkAbout can be an open virtual world for very much any kind of activity with social interaction.

B. Supporting Learning Activities

Teachers can activate the learners by selecting which activities are used in the learning situation. Variation is positive for the learning and active learning leads to a higher degree of knowledge retention. By using different activities, the learning can also become more inclusive to support learners with different needs.

Yee [19] has gathered 273 different learning activities for e.g., brainstorming, comparing notes, sharing findings with peers, giving feedback etc., and while not all of them might suit all teachers and learners, some of these are very suited to be incorporated into WalkAbout as a palette of available learning activities. The application could support this by having pre-defined activities where the participants are moved into specific positions automatically and 3D-screens are presented with suitable pre-loaded specific web-applications.

C. Scripting, Recording and Playback

When recording a traditional lecture online, the result is a movie with typically slides, one or several talking heads and spoken audio. In a virtual world there is instead the possibility to create richer experiences where objects, movement, animations and effects are scripted to create a presentation and learning experience. Using these scripts, a session can be played back in real-time, and the viewers can move around in the experience as a mix of live and pre-recorded content. Here, the teacher could either replace their avatar temporarily with a pre-recorded learning snippet or it could be shown as a copy of the teacher to indicate that it is scripted.

D. The Learning Companion

Another future direction is the learning companion, a virtual entity that can help the learners learn. It can be compared to an animal that can speak and with which the learners can interact, and it can be a supporter of the learner's learning activities.

The companion could be represented by an animal, robot, drone or something else that suits the user but cannot be confused with another user (i.e., not a human form). The companion might evolve and change shape as the learner learns more, e.g., connected to the points mentioned earlier.

The companion would support the learner by giving positive and encouraging feedback to the learner based on their activities and act as an independent actor doing tasks for its user, such as go search for and fetch things, or go to certain places and interact with other users on behalf of their own user. The companion could also be active in the virtual world when their user is not there.

The companion could be backed by an artificial intelligence that learns on demand together with the human learner and could answer questions when needed.

E. The Intelligent Helper Bot

The companion could be extended into a helper bot that acts on its own in the world helping e.g., teachers answer questions or just help users in the virtual world. This could be compared to various chat bots that are available today and the helper bot would be an interface to such a chat bot but with richer interaction possibilities.

The helper bot could be seen as a teacher's assistant that helps with answering questions from the learners in an "intelligent" manner. The helper bot will support the learners' meta-cognitive strategies, which refers to "higher order thinking which involves active control over the cognitive process engaged in learning", chap. 9 in [20]. This will be carried out through support of the learners' planning of how to approach

different learning tasks and evaluating the progress of both the tasks and the approach itself. The method used for the helper bot to support planning and evaluation will be inspired by self-questioning, which has been found especially effective in previous research [20]. In Hattie's [20] meta-synthesis, meta-cognitive strategies were found to have a high effect size (d = .69).

The "intelligence" might come from the fast progress with machine learning in this field where e.g., the GPT3-brain from OpenAI [21] could be utilized.

F. Additional Graphical and Animation Content

Planned functionality include more realistic environments based on scanned interior building data. The landlord of most Swedish government buildings, Akademiska Hus is currently planning to 3D-scan all their higher education buildings and hopefully this data can be made available for usage in WalkAbout as well.

Using computer game engines, the world models can easily be changed and modified and in WalkAbout users themselves will be able to create the world they want to teach and learn in. An application interface to support this is planned. Also, a variant of this is procedural generation of 3D-worlds where the graphical environment is generated based on a set of rules and new worlds could be generated each time a new world is created, or an earlier created world could be reused.

Currently the animations used in WalkAbout are from free sources where many different animations are available. In the future, WalkAbout will support importing users' own animations that are created using real-time capture bodysuits, a technique common in both film and game making. Related functionality also planned is to allow for real-time control of characters using the same bodysuits together with real-time face capture to create livelier avatars in WalkAbout. As extra equipment is needed, this will only be available to select users, e.g., teachers that want to provide a richer experience.

VIII. Discussion and Conclusions

The goal of the WalkAbout project is to create an open learning environment for teachers and learners that complements today's learning tools, both in the classroom and online.

The idea to WalkAbout came out of the fact that many students in online educational sessions do not share video of themselves unless they really must. Instead, it is suggested that the learners express themselves using avatars and animations that they can control in different virtual 3D-environments, much like in many open world games.

When learning is moved into a game-like environment, various game elements can be used to enhance the learning and in WalkAbout this will be done through missions, points and challenges, both personal and in a group to help both weaker and stronger learners learn more.

The virtual learning world is based on the idea of active learning where the learners can actively participate in tasks, and solve problems, but also participate in more passive learning activities such as just listening to a classical lecture.

The game-like environment could in the future allow for recording and playback in novel ways, where a learning session could be scripted and played back in real-time where learners could engage in various ways with the recorded material to become more active in their learning.

Motivation is an important part of learning and the idea of gamification for motivating learners to learn more in the context of WalkAbout must be further investigated. Will e.g., the various missions, challenges and rewards lead to a higher degree of intrinsic motivation, or will it just be an external motivator? According to Csikszentmihalyi [22], teachers should spend less time on transmitting information and more time on trying to stimulate the students' enjoyment of learning and by that achieve better results. A future direction could be to use the 6C method presented by Turner and Paris [23] for how to create a motivating learning environment.

As the development of WalkAbout is still very much in progress, the tool has not really been tested in real educational situations yet but discussions with students and teachers show a great interest in the tool as an alternative to the video conferencing tools that are predominantly being used in higher education today.

To conclude, the WalkAbout environment can also be used for other types of scenarios such as learning with both children and adults out-side of a university context (life-long learning), general work, fairs, or just for fun.

WalkAbout is currently in a proof-of-concept development phase and open testing will commence during the end of 2021. For information about the current status of the WalkAbout project and availability of the tool, please see [24].

Overall, the long-term goal is to use WalkAbout as a general education tool, both standalone and as a complement to our current online teaching tools, as well as an open virtual world application for experimenting with learning and education on all levels.

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