

Hybrid online learning for a software practice course and how it affects students with different self-regulated learning levels

Jian-Wei Lin

Department of Information Technology and Management, Shih Chien University, Taipei, Taiwan

The COVID-19 pandemic has forced universities to make a radical switch from face-to-face traditional teaching (TT) to completely online learning (OL). Thus, many studies proposed the proper OL environment for a specific subject and evaluated its effectiveness. However, few studies have empirically compared the proposed OL environment with TT to determine which has better learning effectiveness. More importantly, an OL environment and the self-regulated learning (SRL) ability of a student interactively influence the student's learning effectiveness. However, few studies have investigated how an OL environment influences the learning behaviours of the students with different SRL abilities. Thus, the aims of this study were to compare the adopted hybrid OL environment with TT and examine how the hybrid OL environment individually influences students with different SRL levels. This study has three significant findings. First, students have better participation rate and work quality in the OL than in TT. Second, the high-SRL and middle-SRL students have higher work quality under the OL than under TT, while the middle-SRL and low-SRL students have higher participation rates under the OL than under TT. Third, while students overall do not particularly favour OL or TT, the middle-SRL students particularly prefer OL.

Implications for practice or policy

- Educators could consider hybrid OL on software practice courses (e.g., Microsoft Office) and programming courses during the COVID-19 pandemic, because most students benefit more from OL than from TT.
- Educators could provide proper assistance for the low-SRL students under the hybrid OL, which could enhance their learning.
- Educators in a TT environment could consider giving students more private space to reduce disturbances, which could particularly benefit introverted students with high-SRL and middle-SRL.

Keywords: traditional face-to-face teaching, online teaching, self-regulated learning, learning effectiveness, preferences

Background

Online learning during the COVID-19 pandemic

Online learning (OL) can be categorised into three environments, namely synchronous OL (e.g., videoconferencing and live chat), asynchronous OL (e.g., lecturers' blogs and social media) and hybrid OL environments (Perveen, 2016; Rinekso & Muslim, 2020). The synchronous OL environment normally involves real-time live lessons delivered through videoconferencing software (Moorhouse, 2020). A synchronous OL environment can raise students' engagement and motivation because teachers can directly monitor the learners' responses during the learning process (Hrastinski, 2008; Rinekso & Muslim, 2020). An asynchronous OL environment provides a learning environment in which the learners and teachers need not be online at the same time. Rodríguez-Paz et al. (2021) indicated that asynchronous learning materials are needed particularly for these students who live in different time zones. However, Flynn et al. (2021) found that student engagement in an anatomy course was often poor in asynchronous online discussion, with the students complaining that the environment does not provide for sufficient levels of interaction in the absence of face-to-face teaching (Swinnerton et al., 2017). Finally, a hybrid OL environment is the combination of synchronous and asynchronous OL in order to obtain the ideal learning environment (Perveen, 2016; Rinekso & Muslim, 2020).

The COVID-19 pandemic has forced universities to make a radical switch from traditional teaching to OL in order to break the chain of virus outbreak (Astuti, 2021) while continuing course instruction (Rinekso &

Muslim, 2020). However, OL had been prevalent for several decades before the pandemic, often playing an auxiliary role to support traditional teaching (TT) in a traditional education setting. To the best of my knowledge, before the pandemic, few traditional educational institutions (universities) completely adopted OL to replace TT over a long period of time (e.g., several weeks, several months or one semester). Although some educational organisations have provided massive open online courses (MOOCs), in which students may acquire professional credits after completing the online courses, MOOCs adopt an asynchronous environment, which cannot easily increase students' engagement and motivation. That is, MOOC environments are autonomous and require students to persist and learn spontaneously, which is not natural for everyone (Lin, 2020). Thus, MOOCs have very low completion rates, with fewer than 10% of students who enrol in a MOOC completing it (Alraimi et al., 2015; Jordan, 2014; Lin, 2020).

Different courses (subjects) may have different teaching modes requiring different OL environments. Thus, many investigations seek a feasible OL environment (either synchronous or hybrid) for a specific course to replace TT during the pandemic. For example, in contrast with many other subjects, English language learning needs real-time interaction with instructors and peers to orally share opinions and experiences in English. Therefore, Rinekso and Muslim (2020) employed synchronous online discussion in higher education during the COVID-19 pandemic for teaching an English language course and found that the students had positive response and were more focused and engaged with the topic available in the discussions. Meanwhile, other researchers also investigated optimal and sustainable OL environments and teaching modes for other specific courses. For instance, Flynn et al. (2021) found that a synchronous OL environment is a viable approach for anatomy teaching for small or large student cohorts during the COVID-19 pandemic, as immediacy in feedback can enhance communication, especially in circumstances where confusion is likely to occur. Guo (2020) also found that for an introductory calculus-based physics class, students who attended the synchronous online teaching during the COVID-19 pandemic had an average test grade drop of 3.5%, while students who did not attend had a drop of 14.5%.

Christian et al. (2021) recommended that educators should consider utilising a mixed synchronous and asynchronous (hybrid) OL format during the pandemic. This format enables experiences and reflection to occur through social interaction during the synchronous portion of the course, and knowledge construction through personal endeavour during the asynchronous portion (Raskin, 2008). Thus, Moorhouse (2020) adopted a hybrid OL environment for teaching an English language course during the pandemic and found that the combination of asynchronous materials allowing students to review as well as synchronous teaching and group discussion can raise student attendance, participation and interaction. Jabbar et al. (2021) adopted hybrid learning for a parasitology course during the pandemic, which received very positive feedback from students. That study lists some tips for online teaching for a teacher, including (a) for asynchronous learning, prerecording lectures and making the video and slide available online in a learning management system, and (b) for synchronous learning, using live sessions (videoconferencing) to promote social, cognitive and peer learning. Rodríguez-Paz et al. (2021) further showed that students prefer a combination of asynchronous learning material and synchronous teaching (via Zoom) for engineering courses during the contingency and lockdown conditions due to the COVID-19 pandemic. Moorhouse (2020) also expressed that a hybrid OL blend of synchronous and asynchronous instruction environments can support learning when face-to-face instruction is not an option.

Notably, although many investigations have concluded that adopted synchronous or hybrid OL environments were feasible options for their specific courses, few empirically compared the adopted OL environments with TT in terms of learning effectiveness. Moorhouse (2020) also stressed that further research to investigate online instructional replacements to TT to deliver courses online during health emergencies is critically needed. Thus, the first aim of this study was to investigate whether the learning effectiveness of students in a software practice course is significantly different between hybrid OL and TT. A hybrid OL environment was selected for comparison based on the tips listed in Jabbar et al. (2021) as described in the previous paragraph. This is because asynchronous materials (e.g., access cloud software, online materials, and teaching videos on YouTube) allow flexibility in when and how students access the resources (Christian et al., 2021), while synchronous modes (videoconferencing) enable instant interactions between teachers and students.

Rodríguez-Paz et al. (2021) noted that students prefer the combination of synchronous teaching (via videoconferencing) with asynchronous material (e.g., particularly YouTube videos of lecture content and demonstrations of physical experiments) for engineering courses during the pandemic outbreak for

completely OL. Similarly, my study also provides asynchronous teaching videos that contain lecture content and software operation process, in addition to synchronous teaching. Specifically, the common teaching mode of a practical software course in a TT environment is described as follows. The teacher typically broadcasts (or projects) their computer screen to introduce related concepts and demonstrate software operations. Students are then required to practice these operations on their computers on their own. This teaching mode in the TT environment can be performed virtually in a hybrid OL environment with some modification. Specifically, a teacher can pre-record the teaching content (i.e., including the introduction of related concepts and the demonstration of software operations) and put it online together with learning materials before a class (for later viewing and download). The teacher launches a videoconference during the class. The teacher can then further broadcast the recorded video, or students can view the online video directly. If a student asks questions during the videoconference, the teacher can immediately respond to the student, presenting the learning materials (slides) again, or screen sharing.

The impact of self-regulated learning (SRL) level on online teaching

Some students may learn or perform better in an OL environment than in a TT environment (Lin et al., 2015; Owens, 2005). Researchers have speculated that learning styles could affect a learner's preference for and performance in OL; for example, OL appeals to students who are self-regulated or self-motivated (Lin & Tsai, 2016; Wu & Chen, 2017). SRL level substantially relates to learning achievement (Lin et al., 2015; Lin & Tsai, 2016; Wang, 2011). The role of SRL level in OL has also recently received attention as much attention as it does in TT (Lin & Tsai, 2016).

SRL ability refers to the extent to which learners are meta-cognitively, motivationally and behaviourally active in their own learning processes (Zimmerman, 2000). Specifically, students with high SRL levels play active roles in learning by setting tasks and appropriate goals; taking responsibility for their own learning; monitoring their own learning and maintaining their own learning motivation (Lin & Tsai, 2016; Wang, 2011). In contrast, students with low SRL levels have academic learning difficulties and low motivation. Since an OL environment is autonomous and requires students to learn spontaneously, the levels of SRL substantially influence individual learning behaviour and achievement in an OL environment (Barnard et al., 2009; Lin et al., 2015; Lin et al., 2016).

Conversely, the cognitive self-regulation of students and their use of cognitive learning strategies can be also influenced by an OL environment because self-regulation is a contextually bound process relating to social interaction (Lin et al., 2015; Lin & Tsai, 2016; Salovaara, 2005). Thus, several works have investigated how different OL environments affect individuals with different SRL levels in terms of learning behaviour and effectiveness (Lin et al., 2015; Lin et al., 2016; McManus, 2000; Wang, 2011). For example, Lin et al., (2016) investigated how an OL environment with peer assistance support influences students with different SRL levels on their OL behaviours. McManus (2000) investigated the impact of a hypermedia learning environment on individuals with different SRL levels. Wang (2011) also investigated how an OL environment with peer collaboration support influences individuals with different SRL levels.

In summary, SRL levels and OL environments influence each other interactively. That is, SRL levels may determine learning behaviour and effectiveness within an OL environment, which in turn may result in students with different SRL levels having different learning behaviour and effectiveness. Again, before the pandemic, few traditional educational institutions (universities) adopted hybrid OL to completely replace TT for a software practice course in the long term. Thus, the effect of a hybrid OL environment on students with different SRL levels in a software practice course and how these students perceive such an environment are still unknown. The second aim of this study was to investigate this issue.

Research questions

The COVID-19 pandemic has forced universities to run courses entirely by OL for several months or even a whole semester. However, before the pandemic, few universities completely replaced TT with OL for such long periods of time. Thus, many researchers have investigated "proper" OL environments (i.e., synchronous or hybrid) for a specific subject (e.g., anatomy, English language, parasitology, physics, engineering) (Flynn et al., 2021; Guo, 2020; Jabbar et al., 2021; Moorhouse, 2020; Rodríguez-Paz et al., 2021). However, few studies have empirically compared the learning effectiveness of an OL environment with that of TT.

Thus, this study adopted a hybrid OL environment for a software practice course, called Digital Image Concepts and Editing, which uses Adobe Photoshop. The experiment let students first experience TT for 3 weeks (three lessons) and then introduced a hybrid OL environment for another 3 weeks (another three lessons). During the experiment, students were asked to upload their assignments for each lesson (i.e., six assignments in total) for scoring by the teacher. The first research question (RQ1) was:

- RQ1: whether students have significant differences on the number of assignments uploaded (participation rate) and scores (i.e., work quality) between hybrid OL and TT.

Additionally, SRL levels and OL environments influence and interfere interactively (Lin et al., 2015; Lin & Tsai, 2016). Owens (2005) also expressed that students with high, middle and low SRL levels might have different learning effectiveness between a TT environment and a diverse OL environment. Thus, how a hybrid OL environment for a software practice course influenced students with different SRL levels in terms of learning effectiveness, especially when adopting a hybrid OL environment for a long period, is still unknown. Accordingly, RQ2 is as follows. Furthermore, this study also used a questionnaire to investigate RQ3 as follows:

- RQ2: whether students with different SRL levels (high, middle, and low) have significant differences in the number of uploaded assignments (participation rate) and assignment scores (quality) between the OL and TT.
- RQ3: whether students with different SRL levels have different preferences between OL and TT, and their major concerns.

Method

Participants and experimental procedure

This research complied with Taiwan ethical guidelines. All the participants were informed of the research purpose and they agreed that their data were collected anonymously. The research respected the personal rights of participants.

This experiment was conducted in two 1-year classes at a Taiwanese university. Each class consisted of about 55 students around 18 years old. The experimental course was Digital Image Concepts and Editing, which teaches how to use Adobe Photoshop to create and edit digital images. Before the experiment, all the students were asked to complete questionnaires (as described in the next subsection) to measure their SRL levels. The students were also informed that some data would be anonymously collected and analysed, and that they were free to drop the class section and take another class section taught by a different teacher. The course was held for one class every Friday morning (8:10–10:00am) and for another every Friday morning (10:10–12:00noon). The same teacher taught the two classes throughout the experiment.

Because the COVID-19 pandemic happened in the middle of the semester, the school suspended TT and changed to OL (i.e., learning from home) later in the semester. Thus, the experimental procedure comprised 3 weeks of traditional TT in a physical classroom (before the pandemic outbreak) and 3 weeks of OL (after the pandemic outbreak), as shown in Figure 1.

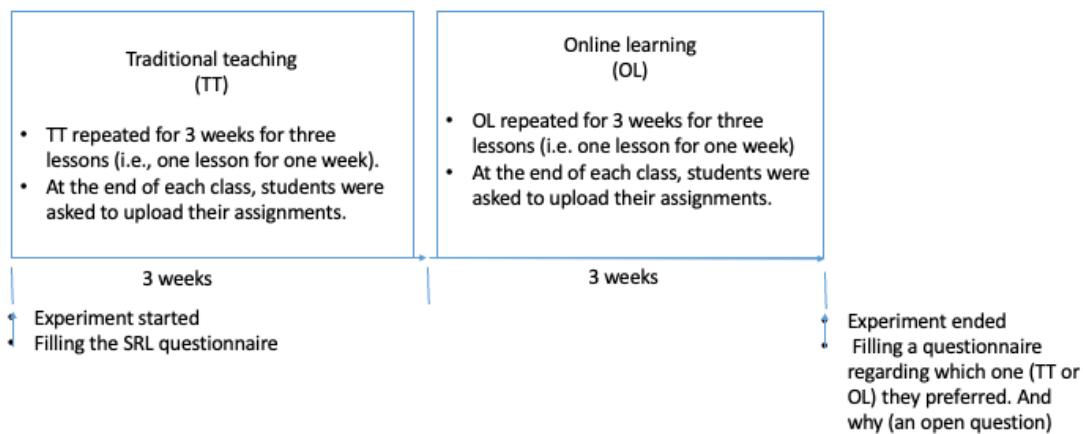


Figure 1. Experimental procedure

Regarding the synchronous system, among several existing videoconferencing systems (e.g., Zoom and Cisco Webex), this study used Google Meet for two reasons: (a) My school uses Google Workspace for Education, providing every student with a Google account to use all Google services (e.g., Gmail, Google Meet). Google Meet automatically shows the real names of students who are logged in, enabling teachers to identify them; (b) Google Meet provides all needed synchronous functions, such as instant messaging and screen sharing. Regarding the asynchronous system, this study used a commercial OL platform provided by my university in which all students are registered in advance, so that students can download materials and upload their assignments and teachers can score the students' assignments and calculate their final scores online.

During the TT class in a physical classroom where every student had a computer to use, the teacher first announced the Internet addresses of learning materials (e.g., Microsoft PowerPoint files) on the asynchronous OL platform provided by my university for download. The teacher then introduced the related important concepts and demonstrated the image creation with Adobe Photoshop on the teacher's computer. Students could see the demonstration through the broadcast of the teacher's screen and could then practise it on their computers. Students who encountered problems could immediately ask the teacher for help. Students were asked to upload their personal assignments to the OL platform within 1 hour of the end of the class for the teacher to score. Thus, the 3-week TT generated three student assignments in total. For example, the first learning unit (week) assignment was to design a web banner (Figure 2a), while the second was to design a restaurant menu (Figure 2b).

This study adopted a hybrid OL environment (synchronous/asynchronous delivery format). As described above, the teacher pre-recorded the teaching content and put it online together with the learning materials (e.g., Microsoft PowerPoint files) on the OL platform (the same as in TT) before the class. During the OL class, the teacher launched a videoconference using Google Meet and announced the addresses of the teaching video and materials, so that students could directly view the online video and access the materials. Students could also utilise Adobe Photoshop to practise their work by using VMware Horizon Client software to connect to my school's virtual machines. Adobe Photoshop was set up as cloud software, and thus students could utilise it anytime at anywhere. Any student who encountered questions during an OL class could ask for help by texting or sharing their screen within Google Meet so that the teacher could immediately help them solving questions online. Alternatively, a teacher could create another private meeting and ask the student to join, so that they could discuss and solve the question by oral explanation and screen sharing. At the end of a class, students were asked to upload their personal assignments to the OL platform within 1 hour after the end of the class for the teacher's scoring. Similarly, the 3-week OL generated three assignments in total. For example, the first learning unit assignment was to design an advertisement of a programming competition (Figure 2c), while the second was to design an advertisement for a new housing building for sale.

In completing their assignments in the TT or OL class, students had to organise both the methods and skills that they had learned in the class; monitor their actions and progress; check outcomes and results; revise and refine the final work in order to meet the teacher’s requirements and reflect on all decisions made and actions taken during the class. Finally, after the completion of the experiment, all students were asked to complete an online questionnaire asking which teaching mode (TT or OL) they preferred and why (an open question).



(a) Design a web banner: an example of a student work



(c) Design an advertisement of a programming competition: an example of a student work:



(b) Design a restaurant menu: an example of a student work:

Figure 2. Learning units and examples of students’ personal work

Instruments

The students’ SRL levels were assessed with a questionnaire devised by Lin and Tsai (2016). It has five categories and 20 items with a 5-point Likert scale from *strongly agree* (5) to *strongly disagree* (1). The five categories are “self-monitoring”, “deep strategy use”, “shallow processing”, “persistence” and “environmental structuring.” Items 1 to 7 relate to “self-monitoring”. Items 8 to 11 relate to “deep strategy use”. Items 12 to 15 relate to “shallow processing”. Items 16 to 17 relate to “persistence”. Items 18 to 20 relate to “environmental structuring”. The Cronbach’s alpha values were 0.86 for the whole questionnaire, 0.84 for “self-monitoring”, 0.82 for deep strategy use”, 0.92 for “shallow processing”, 0.82 for “persistence”, and 0.89 for “environmental structuring”

Under normal distribution, the most suitable ratios for students with high-, medium- and low-SRL levels are 27%, 46%, and 27%, respectively (Lin & Lai, 2014). Hence, the students were further divided into three groups by their SRL questionnaire scores. The students whose scores were in the top 27% were allocated to the high-SRL group; those whose scores were in the bottom 27% were allocated to the low-SRL group, and the rest to the middle-SRL group. In this study, 101 students officially finished the experiment; thus, the high-SRL and low-SRL groups each had 27 students, while the middle-SRL group had 47 students.

Data collection and analysis

The upload times of personal assignments were obtained from the OL platform. The teacher scored the assignments based on the rubric: correctness, creativeness, special effects and overall, each accounting for 25%. For example, correctness refers to the levels of a student attaining the teacher’s requirements, such as the direction of the theme and the required text and images, while special effects refer to whether a student correctly used the specific special effects.

A student’s assignment upload time was measured as the participation rate. The average score of a student’s uploaded assignments was further calculated as the work quality of the student. For example, a student who uploaded two assignments and obtained scores of 80 and 90 had an average score of 85 (= (80+90)/2).

Statistical analysis was undertaken by paired-sample *t* tests, which determine whether the mean difference between two sets of observations has significant differences. This *t* test is based on the differences between the values of a single pair; that is, each subject (sample) is measured twice, resulting in pairs of observations. The formula of the paired-sample *t* test is defined as follows, where *d* represents the difference per paired value and *n* represents number of samples:

$$t = \frac{\sum d}{\sqrt{\frac{n(\sum d^2) - (\sum d)^2}{n - 1}}}$$

Results

Results for RQ1

To analyse RQ1, paired-sample *t* tests were performed on students’ assignment upload times and average scores between TT and OL. As shown in Table 1, both average numbers of uploads and scores were significantly lower in TT than in OL, with $t = -8.00, p < 0.05$ for upload times and $t = -3.50, p < 0.05$ for average scores.

Table 1
Results of the paired-sample t tests

Items	TT			OL		<i>t</i> value
	N	M	SD	M	SD	
Upload times (participation rate)	101	1.93	1.00	2.70	0.67	-8.00*
Average scores (work quality)	101	78.63	28.31	89.45	16.60	-3.50*

Results for RQ2

Regarding RQ2, Table 2 shows the numbers of uploads of high-SRL, middle-SRL, and low-SRL students in each learning unit (i.e., whether participated or not for a unit) in TT and OL. Obviously, almost all of the high-SRL students participated (i.e., uploaded their assignments) for every unit in TT and OL. The middle-SRL students had fluctuating numbers of participating learning units in TT, but steady high numbers in OL. The low-SRL students had low numbers of participation in learning units in TT; notably, they had a higher number of participation in learning units in OL than that in TT.

Table 2
Number of students who uploaded their assignments for each unit within TT and OL

SRL levels	TT			OL		
	Unit 1 (<i>n</i>)	Unit 2 (<i>n</i>)	Unit 3 (<i>n</i>)	Unit 1 (<i>n</i>)	Unit 2 (<i>n</i>)	Unit 3 (<i>n</i>)
High (<i>N</i> = 27)	27	26	27	27	27	27
Middle (<i>N</i> = 47)	28	20	42	47	46	44
Low (<i>N</i> = 27)	7	2	13	20	12	16

Note. *N*: the actual number of students; *n*: the number of students who uploaded their work

The paired-sample *t* tests were further applied to compare the numbers of uploads and average scores of students by SRL level (i.e., high, middle, and low) between TT and OL. Table 3 shows the comparison results. The mean upload numbers of high-SRL students did not significantly differ between TT and OL, as they uploaded their assignments for every unit in both TT and OL. However, the mean of the average scores (mean = 94.1) was significantly higher in OL than in TT (mean = 89.9) ($t = -7.82, p < 0.05$). For the middle-SRL students, the mean of the both upload numbers and average scores were significantly higher for OL (2.88 and 92.4, respectively) than for TT (1.88 and 80.6, respectively) ($t = -7.32, p < 0.05$ and $t = -3.11, p < 0.05$, respectively). For the low-SRL students, the mean of the upload numbers was significantly higher for OL (2.00) than for TT (0.92) ($t = -4.66, p < 0.05$), but the mean of the average scores did not significantly differ between OL and TT.

Table 3

Results with paired-sample *t* tests on upload times and average score of students with different SRL levels (i.e. high, middle, and low) between TT and OL

Group	Item	TT		OL		<i>t</i> value
		M	SD	M	SD	
High-SRL students	Upload times	2.89	0.31	3.00	0.00	-1.80
	Average scores	89.9	2.16	94.1	1.39	-7.82*
Middle-SRL students	Upload times	1.88	0.86	2.88	0.33	-7.32*
	Average scores	80.6	25.4	92.4	3.31	-3.11*
Low-SRL students	Upload times	0.92	0.71	2.00	1.02	-4.66*
	Average scores	61.3	40.5	77.9	31.2	-1.59

* $p < 0.05$

Results for RQ3

Table 4 shows the preferred teaching modes (TT or OL) of students with different SRL levels. Overall, students did not particularly favour either OL or TT, as 25 students preferred TT, 43 students were neutral and 33 students preferred OL. Notably, the high-SRL students did not particularly prefer TT or OL; the middle-SRL students clearly preferred OL ($N = 20$) over TT ($N = 10$) with neutral ($N = 17$), while the low-SRL students did not particularly prefer TT or OL, similarly to the high-SRL students.

Table 4

Results from questionnaire about preference (TL or OL)

SR Levels	Prefer TT (<i>N</i>)	Neutral (<i>N</i>)	Prefer OL (<i>N</i>)	Total
High	8	13	6	27
Middle	10	17	20	47
Low	7	13	7	27
Total	25	43	33	101

Note. *N*: Number of students

Analysis of responses to the open question indicates that students who preferred TT were mainly concerned about “ease of access to assistance and interaction”, while students who preferred OL were mainly concerned about “facilitation of self-paced learning”. Table 5 summarises these responses.

Most students who preferred TT, naturally, (i.e., 50% high-SRL students, 80% middle-SRL students, and 100% low-SRL students) thought TT was more convenient for accessing assistance and interactions than OL. Interestingly, a lower SRL level is indicated a higher ratio (50%, 80%, and 100%) of seeking assistance and interactions. The responses to the open question had the similar expressions: “It is much convenient for asking helps and physically interacting with peers and teachers,” “Questions can be understood effectively and solved immediately when the teacher and peers explain face-to-face through watching or operating my physical screen.” One student particularly expressed, “Sometimes I can show my creative or ludicrous or hilarious work to my classmates which adds more fun in the class.”

Most students who preferred OL (i.e., 100% high-SRL students, 75% middle-SRL students and 43% low-SRL students) emphasised that OL facilitates self-paced learning more than TT. Interestingly, students with higher SRL level had more (100%, 75%, and 43%) self-paced learning concerns. Typical responses to the open question were “I can fast forward or speed up the parts that I understand,” “I can review the parts that were complicated or I did not understand via the online video.” Some high-SRL students stated concretely, “Under TT, the teacher has to wait that almost everyone completes the current step, before moving to the next step of instruction. Under OL, no-one needs to wait for anyone else by viewing the teaching video.”

Table 5
Results of preference (TT or OL) of high-SRL, middle-SRL and low-SRL students

SRL levels	Prefer TT because of ease of access to assistance and interaction		Prefer OL because of facilitation of self-paced learning	
	No.	Percentage	No.	Percentage
High	4 out of 8	50%	6 out of 6	100%
Middle	8 out of 10	80%	15 out of 20	75%
Low	7 out of 7	100%	3 out of 7	43%
Total	19 out of 25	76%	24 out of 33	72%

Discussion and implications

Discussion for RQ1

An unexpected finding from RQ1 is that students had both significantly higher upload times (participation rate) and average score (work quality) in OL than in TT. Regarding participation rate, my results echo Flynn et al. (2021) that students generally engaged well in online discussion, and sometimes even better than in TT. Regarding work quality, my results confirm Iglesias-Pradas et al.'s (2021) finding that the overall academic performance of students was significantly better in emergency remote conditions (i.e., OL) than in TT. These results echo Brecht's (2012) findings that video lectures reduce dropout rates and improve course grades.

Experimental results indicate that more students preferred OL than TT (i.e., 33 versus 25, as shown in Table 4). Among the 33 students who preferred OL, 72% students (Table 5) expressed that they could learn on their own pace and learn effectively. Their responses also echo Brecht (2012) and Simpson (2006) that video lectures give students control of the lecture, enabling them to replay segments and stop the lectures as they study to understand the content, and skip topic segments that they understand. Students can thus adjust the instructor's delivery speed and topic selection to match their individual learning pace and interests. They can view the lecture when and where they study most effectively (Brecht, 2012). Overall, OL facilitates self-paced learning and has flexibility to satisfy individual learning needs, and thus learning becomes effective as a whole. The next section considers how the OL environment influenced students with different SRL levels, and how it was perceived by them.

Discussion for RQ2

All the high-SRL students had almost full participation in every learning unit whether in TT or OL. This could be because high-SRL students are good at autonomous learning and they are active learners in both learning environments (Lin & Tsai, 2016). Notably, their work quality was significantly higher in OL than that in TT. All 6 high-SRL students expressed that OL give them more control of the lecture and enabled them to learn at their own pace (Table 5). High-SRL students are good at time management, effort management and structuring their environment (Lin & Tsai, 2016; Pintrich, 1999; Zimmerman, 2000). People have different learning speeds; thus, the high-SRL students often finished the required assignments ahead of the learning schedule during the experiment. The OL gave them more flexibility and sufficient time to refine their works, compared with TT. This is one possible reason that they performed better in assignments in OL than in TT.

The middle-SRL students had low and fluctuating participation rates (i.e., upload times) in TT, relative to the high and steady participation rates in OL. Moreover, the middle-SRL students also had significantly better work quality in OL than in TT, and thus benefited most among the three groups. In addition to the self-paced learning of OL, this study further speculates that introversion and extroversion also play an important role in promoting the work quality of high-SRL and middle-SRL students in OL. Flynn et al. (2021) stated that some students feel more confident interacting in virtual than physical environments and may benefit from increased engagement by moving teaching online. Extroverted students favour the physical presence of other people (Astuti, 2021) and are energised by social interaction (Russell, 2002), while introverted students prefer fewer people to be present (Astuti, 2021) and in particular favour the online environment, which is a comfortable space in which is conducive to presenting their opinion or questions (Russell, 2002). In other words, many introverts benefited from the move away from a physical

working environment which is more suitable for extroverts. Constant conversation from neighbouring peers can be draining for introverts. Within an OL, students can study the video lectures without environmental distractions, at their convenience (Brecht, 2012). Two high-SRL students and two middle-SRL students, who preferred OL, expressed that they could focus on learning without disruptions or disturbances from peers, which easily happen in physical classes (e.g., neighbours' chit chat or someone's phone ringing). With Google Meet, most students mute their microphones and only the teacher's voice is heard. Consequently, within OL, inverted students, particularly with high-SRL and middle-SRL levels, have more time to reflect their thoughts and learning. Thus, the above phenomenon helps explain why introverted students with high- and middle-SRL levels possibly become more productive (i.e., have higher work quality) while learning from home. However, such speculation needs further investigation.

The low-SRL students had higher participation rates in OL than in TT. Interestingly, some particularly praised that with OL they could study at home without going to school very early in the morning, increasing the opportunities of attending classes and uploading personal assignments. These results are in line with Brecht (2012) that weak students especially benefit from OL, with significantly reduced course withdrawal rates. However, their work quality does not significantly differ between OL and TT. Although low-SRL students particularly stressed the convenience of acquiring assistance (Table 5), OL does not provide them with a better environment for obtaining assistance when encountering questions. Additionally, their lower learning motivation means that they dedicate less time to an academic task, and often exhibit maladaptive and counterproductive behaviours like procrastination and disengagement (Iwamoto et al., 2017). These are possible reasons why they had little progression on work quality even in OL.

Discussion for RQ3

Overall, students did not particularly favour OL or TT. However, the middle-SRL students particularly prefer OL. This could be because OL facilitates self-paced learning and is more flexible than TT, and most importantly they benefited most in terms of participation rate and work quality, compared with high- and low-SRL students. Additionally, some students preferred TT mainly because it allowed them to access physical assistance from teachers and peers instantly and conveniently. This result echoes the finding of Kramarski and Mizrachi (2006) that students favour TT because of physical interactions among the teacher and classmates, the feeling of shared learning experiences and working together. Notably, students with lower SRL levels who favour TT are more concerned about facilitation of assistance accessing and interaction. For example, one high-SRL student expressed that communication (help seeking) with the teacher was not a concern because the teacher had email and was online with Google Meet during a class. A possible reason for the difference is that low-SRL students may have lower self-efficacy than high-SRL students and exert less effort with less confidence when performing a learning task (Lin et al., 2015; Pajares, 2002). Low-SRL students require handy and immediate help when encountering obstacles during learning.

Students preferred OL mainly because it facilitates self-paced learning. Notably, students with higher SRL level who favour OL is are more concerned about facilitation of self-paced learning. Highly self-regulated learners actively engage their learning environment, use resources effectively, organise and rehearse key information and hold positive motivational beliefs about their capabilities and the overall value of learning (Iwamoto et al., 2017; Schunk & Zimmerman, 1994). Thus, all 6 high-SRL students expressed that they could learn on their own pace because everyone has a different learning speed. Some expressed that finishing the learning task ahead of schedule enabled them to write some notes or spend the remaining time on other interesting activities.

Implications and conclusion

In the past, OL often played an auxiliary role to support TT; few traditional educational institutions (universities) completely adopt OL to replace TT for a long time period before the COVID-19 pandemic. Thus, many investigations have sought feasible OL environments for specific courses during the pandemic. This study first adopts a hybrid OL environment for a software practice course. Additionally, the SRL levels of a student and an OL environment may influence and interfere interactively with the learning effectiveness of a student. Thus, this study further investigated how students with different SRL levels perform and how they perceive and respond in the hybrid OL environment.

This study finds that students have more participation rate and better work quality in the OL environment than in the TT environment. Furthermore, the high-SRL and middle-SRL students have better work quality in the adopted OL environment than in the TT environment, while the middle-SRL and low-SRL students have higher participation rates in the adopted OL environment than in the TT environment. Finally, overall, students did not particularly favour OL or TT, but the middle-SRL students particularly prefer OL. Moreover, students with lower SRL levels who favour TT generally are more concerned about being able to access assistance and interaction. Students with higher SRL levels who favour OL are more concerned about facilitation of self-paced learning.

Results in this study indicate suggest that higher-level educators can consider the hybrid OL mode (as described before) on other software practice courses (e.g., Adobe Premiere Pro, Microsoft Office, Excel) or even programming courses during the COVID-19 pandemic outbreak. This is because most students benefited more from OL than from TT in terms of participation rate and work quality, except for low-SRL students who still had low work quality in OL as in TT. Furthermore, a course that requires students to upload their creative works for the mid-term and final term instead of having tests can be fully OL. However, a course with mid-term and final tests for such courses may require students to have the tests in a physical classroom because preventing students from cheating in online tests is still a challenge.

Additionally, low-SRL students seem to have particular concern about the convenience of acquiring assistance in a (hybrid) OL environment. An educator in an OL virtual conference can simultaneously set up another virtual conference room, encouraging low-SRL students to join it to ask for help privately from the teaching assistants. This measure may also enhance their work quality. Alternatively, educators in a TT environment can consider giving students more private space to reduce disturbances from the environment, such as reminding students to turn off phones and not to chit-chat with neighbours, or installing clapboards between students' seats. These measures can particularly help introverted students with high-SRL and middle-SRL levels not to be distracted and to further focus on their learning. I speculate that the adopted OL environment particularly benefits the introverted student with middle- or high SRL levels in terms of learning effectiveness, which is also very worthy for further investigation.

The OL experiment was carried for only 3 weeks rather than one semester. According to Lin (2020), whose experiment lasted for one semester, users' continuance intention of using OL environments is determined by their satisfaction and perception of usefulness. In this study, students perceived that the hybrid OL environment was useful and could enhance learning effectiveness, indicating a high continuance intention of using the hybrid OL environment for even longer (i.e., one semester) (Lin, 2020; Lin & Lai, 2019). However, Lin (2020) further found that the level of SRL ability (low or high) of students significantly moderates the relationship between their continuance intention of using OL and actual continuance usage. Furthermore, Lin and Lai (2019) asserted that continuance intention of using OL significantly predicts actual continuance usage for high-SRL students but not for low-SRL students. One of main reasons is that high-SRL students are intrinsically more persistent, active and aggressive in learning than low-SRL students (Lin, 2020; Lin & Lai, 2019). Thus, the results of using the proposed hybrid OL environment for one semester, may differ from this study, particularly for the portions of the low-SRL students. However, such speculation still requires further investigation. Moreover, it is unclear whether the results in this study are applicable to other subjects (e.g., mathematics) or high schools. However, I believe that the interactive influences between other OL environments (for different subjects) and SRL levels may differ from the findings of this study, and these are also worthy for future study.

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Corresponding author: Jian-Wei Lin, jwlin@g2.usc.edu.tw

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Please cite as: Lin, J-W. (2022). Hybrid online learning for a software practice course and how it affects students with different self-regulated learning levels. *Australasian Journal of Educational Technology*, 38(5), 77-89. <https://doi.org/10.14742/ajet.7678>